# POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION


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Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.


MAY
1934

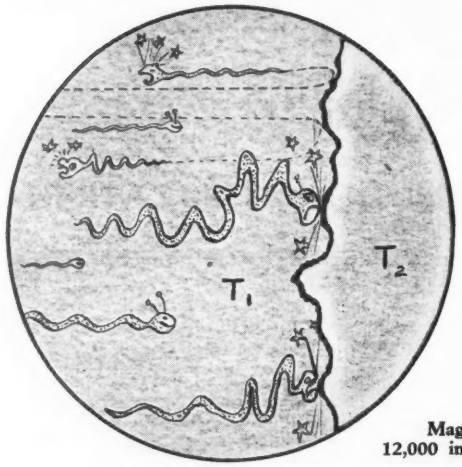
Vol. XXXVIII., No. 5

Published on the first of each month, copyright 1934 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editor. R. E. TURNER, Managing Editor.
A. W. KRAMER, RICHARD H. MORRIS, Associate Editors.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January 1 issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January 1 issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue 19,700




Magnified 12,000 imaginations

# FOILED!

IT IS NOT OFTEN that a publication is privileged to present as remarkable a photograph as the one shown above, indeed we feel quite certain that nothing like it has ever been shown before. This is a photomicrograph made in our own research laboratories, showing the action of aluminum foil insulation upon heat waves. It shows how the heat waves are foiled in their desire to go from $T_1$ to $T_2$, by the bright surface of the metal; how after a futile attempt to pass through the barrier they turn around in disgust and retrace the path over which they came.

We are very proud of this photograph, for it involved a matter of twenty years of scientific research to produce it. These are unusual heat waves. Note the mean looking specimen in the center of the field, a splendid example if there ever was one. As a matter of fact when our chief microscopist saw it he was so elated he upset the photomicrographic apparatus in his excitement and we haven't been able to get it working since. Had it not been for the timely assistance of our staff artist who is endowed with a fertile imagination, we would not have been able to present this picture.

The principle which accomplishes thermal insulation by reflection of radiant heat from a bright surface is not new, it was known as far back as 1850, but its practical application is comparatively recent and depended upon the development of aluminum foil. The use of metal, in itself an excellent conductor of heat, as a material for thermal insulation is extremely interesting, a paradox which only a thorough understanding of fundamental physics could evolve. In the article on page 241 we present further aspects of this development for those who may be interested. We can assure you, however, that there are no photographs in it than can possibly equal ours on this page.

* * *

In an age of intense competition, when chain stores crowd out "independents," when buses and air planes encroach upon the business of the railroads, and when radio "hurts" the newspapers it should not surprise us to find that boilers are suffering from competition by other apparatus in the steam generating plant, and yet to see the evidence of this competition as presented in the article on page 223 is somewhat startling. Since 1920 the required amount of boiler heating surface to produce a pound of steam of certain heat content has decreased some 60 per cent. In other words, to produce a given quantity of steam the amount of heat supplied by the boiler today is only about 40 per cent of what it supplied in 1920. The rest is furnished by the feedwater heater, the superheaters and reheaters. Judging from the curves depicting this trend in heat balance, it seems that in time the boiler, like the horse car and the bustle, will disappear entirely.

* * *

Necessity is the mother of invention. At Wyandotte, Michigan, some 4 years ago the Municipal Service Commission decided to build a new municipal power plant. Plans were made for a 10,000 kv.a. plant and in 1932 excavations were started. In 1931, however, the Commission loaned the City $141,000 to defray current expenses expecting that the money would be returned. It was not, however, and this left the Commission with insufficient funds to proceed with the construction of the station. So they built the boiler house, a fine modern structure, and then rebuilt one of the old steam turbines in their old plant, increasing its capacity from 2500 to 3000 kv.a. This unit they placed in the center of the firing aisle in the boiler house. Thus they met the immediate requirement for more power and at the same time provided an arrangement which will fit in with their future load demands. This plant is described on page 226.

* * *

Hendley Blackmon who wrote "Tubes May Solve Your Problem" in this and the preceding issue, has the knack of interpreting complex phenomena to those who possess an interest in but have not specialized in a particular subject. This article on vacuum tubes we believe is unusually clear and it should help to explain many things about vacuum tubes to those who thus far have had little occasion to use them.

After reading Mr. Blackmon's article, you may be better prepared to understand the action of the "Relaxation Inverter" as described on page 235.

Perhaps you will wonder what in the name of heaven a Relaxation Inverter is or what it is supposed to do. Well, without giving the secret away here we can assure you that it is quite a remarkable device and that it does things which not so very long ago were thought impossible. As yet it is only a baby, but it is a promising "young one," and it looks as though it may have a big future. It is a member of the famous thermionic family which alone should be sufficient to expect a great deal of it, for thus far all the members of that illustrious family have made names for themselves.

# WITH THE EDITORS

## Routine Control—a Machine Function

DESIGNING ENGINEERS have made the boast that they can design equipment that can perform automatically any specific operation which can be done manually. This rather broad claim is becoming more and more in evidence as the scientific age advances. The sewing machine is one of the historic examples, but the simple machine has been developed to the point where special machines will sew several seams at the same time, hem, pucker, pleat or perform any number of complicated stitches with a rapidity undreamed of before the invention of the sewing machine. The self-binding harvester which took a great step forward with the invention of the knotter is another historic example of mechanical devices for performing tedious manual tasks. These, however, are extremely simple devices compared to modern automatic screw machines, electric lamp manufacturing machines, automatic bottle making machines, printing presses, and numerous other machines that have been developed to cut down production costs.

Another class of equipment, however, which has been developed to control physical and chemical conditions of industrial processes has made rapid advancement during the past few years but is in reality only on the threshold of its possibilities. In the power plant field, the steam engine speed governor is a classic which took many years to perfect, the damper regulator to control boiler pressure is another device with an interesting history of development, also steam traps, pump governors, pressure and temperature regulators, feedwater regulators, voltage regulators and a score of others have laid the foundation for more complicated and intricate systems of control that are far more accurate in many instances than could be obtained by human adjustments.

During the past few years another class of devices for control purposes has been developing rapidly but is yet barely on the threshold of its usefulness. This class employs the principles of electronics and has the advantages of extreme speed, mechanical simplicity and response to such minute forces as changes in light and sound intensities.

Development of all such equipment has taken years of time, first in applying scientific principles to control equipment, then in perfecting designs and, through it all, the building up of confidence in operatives that such equipment can be depended upon to function properly. It is indeed difficult to comprehend control devices that will react to correct changes in conditions just as a human does through the exercise of his five senses, yet the scope of such devices far exceeds human ability and it is only through an understanding of the underlying principles involved that perfect confidence can be attained. In one generation, power plant practice has done away with the necessity of back breaking labor and is well on the way to universal automatic control and when that time comes the men in charge must truly be scientists versed in the practical application of such sciences as mathematics, physics, chemistry and mechanics.

## Electrical Lubrication

ELECTRICITY is playing a more important and more intimate part in industry than was thought possible even a few short years ago. Not only does it do work but it is now being utilized for such an unusual service as lubrication. When a current of electricity is passed through a mixture of clay and water, moisture is concentrated at the negative electrode. This phenomenon depends upon cataphoresis, migration of particles in suspension to the positive electrode, and endosmosis, the travel of liquid through a porous medium to the negative electrode when subjected to an electrical current.

Practical use is being made of endosmosis in stiff-mud brick machines by passing an electric current from a suitable positive electrode to the portion of mold where lubrication is desired. Efficiency of electrical lubrication is nearly as great as when oil is used and is probably as good or better than steam. Direct current must be used and the maximum permissible voltage is about 200. The presence of electrolytes increases the current flow and moisture transfer so that the addition of hydrochloric acid to clays low in soluble salts has been found advantageous.

Another application is in the drying of ceramic shapes. Alternating current passed through clay bodies meets considerable resistance and this resistance loss causes a temperature rise which is practically uniform through the specimen. This gives uniform heating, freedom from cracking and is more rapid in air at atmospheric temperature than is possible in a commercial drying oven. The cost at present is high and is used only for large and special shapes which require days or weeks for drying. The main difficulty seems to be in securing electrodes to maintain contact during the entire drying period.

American industry has pointed with pride to the fact that there has been little or no diminution of research activities during the depression period and evidence is brought forth every day that this activity has produced results which are slowly but surely changing the fundamentals of our industrial processes. In all of this work, electricity plays the leading part.

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CENTRAL STATION development in the 50 yr. since Thomas A. Edison started the Pearl St., New York, station in Sept., 1882, is evidenced by growth of the system thus given a start. From a 750-hp. plant serving a square mile area, with 59 customers connected to 15 mi. of underground cable, this and allied systems have spread to cover Manhattan, the Bronx, Brooklyn and Queens, with 35,000 mi. of cable serving millions of customers from plants of 3,180,000 hp. capacity.

# New Garfield Plant *of the*

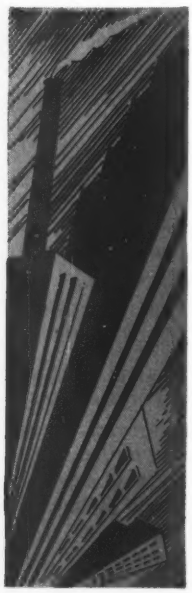
**450 Lb. Pulverized Coal Fired Boilers, Water Cooled Furnaces, Air Heaters, Flue Gas Scrubbers, 2000-kw. Condensing Extraction Turbines Feature this Splendid New Plant***

By FRANK L. BRADLEY
Construction Engineer, Forstmann Woolen Co.

DURING THE PAST year the Forstmann Woolen Company completed and put into operation a new power station supplying both electric power and steam to its plant at Garfield, N. J. This new station was built adjacent to but outside of the immediate manufacturing area. Consequently, when it replaced the former boiler house and engine room, the old structures were converted into a machine shop and manufacturing buildings, for which they were especially desirable on account of their central location in the plant.

Analysis of the power and steam requirements of the plant, and of the economics of these requirements, had indicated desirability of replacing the existing power house facilities. The investigation, which took into consideration the load factors and characteristics, and the equipment best suited, was made in conjunction with a similar study for the company's other plant at Passaic, N. J.

At the Garfield plant the manufacturing processes require steam at both 100 lb. and 20 lb. pressure, and during the winter months there is added a considerable demand for heating steam, which is taken from either the 100 lb. or the 20 lb. system. Heating, however, is done principally with 20 lb. steam and provision is made for changing over the entire heating system to 20 lb. pressure if the cost of the additional lines is justified in the future. The studies showed that it was most economical to install boilers with a working pressure of 450 lb. per sq. in. because this pressure permitted generation of the major portion of the power requirements with the main turbine generators operating condensing with steam extraction at 20 lb. pressure and with a smaller turbine generator exhausting against a back pressure at 100 lb. Since the steam is distributed through existing lines which were not designed for high temperatures, it was not deemed advisable to use steam above 600 deg. F. on account of periods when the lines may be supplied directly through reducing valves.



As far as feasible the power station auxiliaries are driven by turbines. By establishing a common 20 lb. system for both the extraction steam and the auxiliary exhaust, steam can be taken as required for feedwater heating and any excess exhaust is automatically disposed of to the plant. Reducing valves are provided to supply steam to both the 100 lb. and the 20 lb. systems for makeup or for emergency.

A study of the fuel situation prompted a change from the use of anthracite coal to the use of bituminous coal. The lack of tidewater facilities at the selected site and the fluctuations of the oil market eliminated oil as the basic fuel. It was decided, therefore, to design the plant for the use of pulverized coal, and to use fuel oil for ignition and minimum load services.

The power station is conveniently located at the western end of the manufacturing area, or the end toward the river. This arrangement permits storage of coal away from the manufacturing buildings, where dust nuisances would present a serious problem, and provides excellent means for distribution of power and steam to the various manufacturing buildings by pipe tunnels and underground duct lines. Inasmuch as the new power station site is not far removed from the old engine room it was possible to use the existing intake and discharge lines for handling the circulating water from the Passaic river. Adequate space has been left around all sides of the power station so as to impose no serious restrictions upon future expansion.

Architecturally, the building is simple and unadorned, being constructed of selected common brick. The interiors of the boiler and turbine rooms are finished with a selected common brick laid up in simple design without ledges and dirt collecting corners. The walls have been painted cream for greater diffusion of light and have a dark green dado with concrete sanitary base to promote cleanliness. The floors are of reinforced concrete with granolithic finish and have been waterproofed and hardened to prevent dusting and deterioration. All exposed steel and iron work is painted black.

The boiler room is on the north side of the turbine room, and an extension to the west end of the boiler room houses an office, a laboratory, fuel oil and lubricating oil rooms, and the water treating plant. The water treating plant includes all of the water treating and water storage facilities for the power plant and

* A preliminary description of this plant was published in the Nov. 1933 issue.

# Forstmann Woolen Company

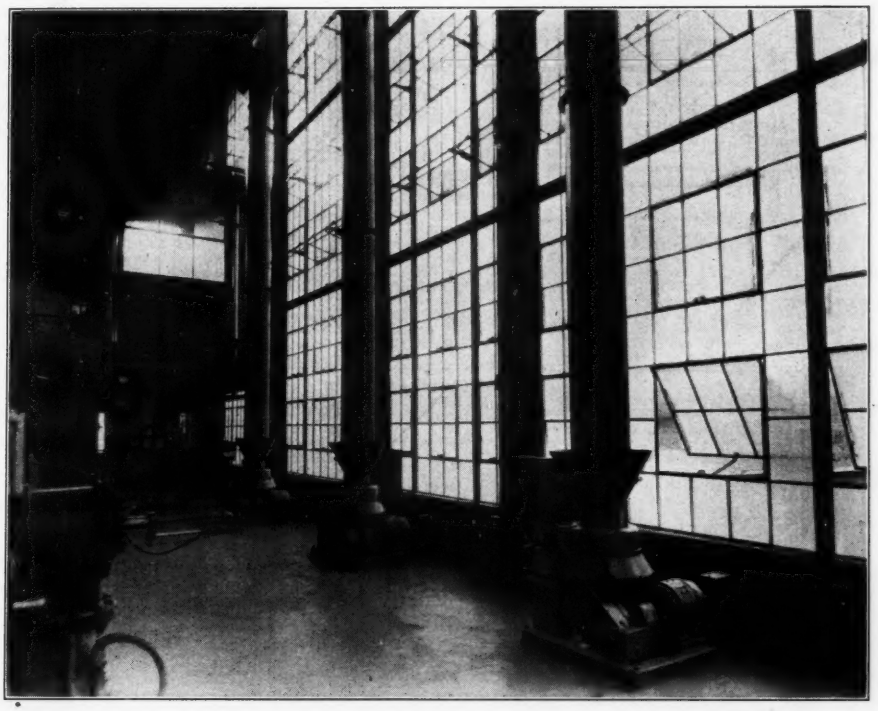


Fig 1. View on Operating Floor Showing Feeders to Pulverizers in the Basement

process requirements. The laboratory contains equipment for continuous sampling and testing of river, city, treated and deaerated water, and of steam samples.

The electrical bay, located on the south side of the turbine room has been arranged with the switchboard panels on the main operating floor and with all the circuit breakers and distribution equipment in a separate, completely enclosed, room below the switchboard. This arrangement places all of the control equipment under the supervision of the turbine room attendant, eliminates unnecessary traffic in the oil circuit breaker room, and provides ample space for work on the electrical equipment when necessary.

The coal storage plant has been designed to provide a bunker capacity of 250 tons and a yard storage capacity of normally approximately 2500 tons. Coal is delivered to a track hopper, and from there to a crusher and conveyor system having a capacity of 50 tons per hour. The coal received is "run-of-mine" and the crusher, an American ring roll type, having a 90 ton per hr. capacity, prepares it for bunker storage or bypasses it for yard storage. The coal is delivered from the hopper to the crusher by an apron feeder, and from the crusher it is discharged to an 18-in. inclined belt conveyor for delivery to the bunker or to outside storage.

To reduce "dead" space in the bunkers to a minimum, three outlet spouts from the bunker have been provided to each pulverizer feeder chute, which discharges to coal scales where the weight of fuel to each pulverizer is recorded. The control of coal feed is effected by a d.c. motor driven table type feeder for each of the three pulverizers. These feeders are located on the operating floor in front of the boilers where they are under the constant attention of the operator.

Coal discharges by gravity from the feeders to pulverizers of the Atrita type located in the basement below the operating aisle. The pulverizers are located in the basement in order to avoid expensive supports, eliminate objectionable vibration and to provide space and facilities for ease of maintenance of this equipment. Each of two pulverizers are connected to one boiler, while the third can serve either boiler. One pulverizer will carry its boiler up to about two-thirds of the maximum capacity, while for higher loads the spare pulverizer must be run also. Hot primary air, taken from the forced draft system, is used to dry the coal in the pulverizers. Coal is burned in one flare type burner per boiler provided with an oil burner for ignition and low load requirements. Direct current is used for driving the coal feeders and the motor driven fuel oil pump so that they can be run from the station battery in an emergency or for starting.

The boiler installation consists of two bent tube boilers designed to deliver 80,000 lb. of steam per hour at 450 lb. pressure and 610 deg. F. total temp. Each boiler is 19 tubes wide, has one dry steam and three water-drums, and has 6520 sq. ft. of boiler heating surface. The boiler drums are fusion welded and further protection against corrosion in the boiler and water walls is provided by the application of Apexior to all boiler drums and tubes, and to the water wall drums, headers and tubes.

Each boiler has one superheater of the single pass convection type located above the second row of boiler tubes, each superheater having approximately 530 sq.

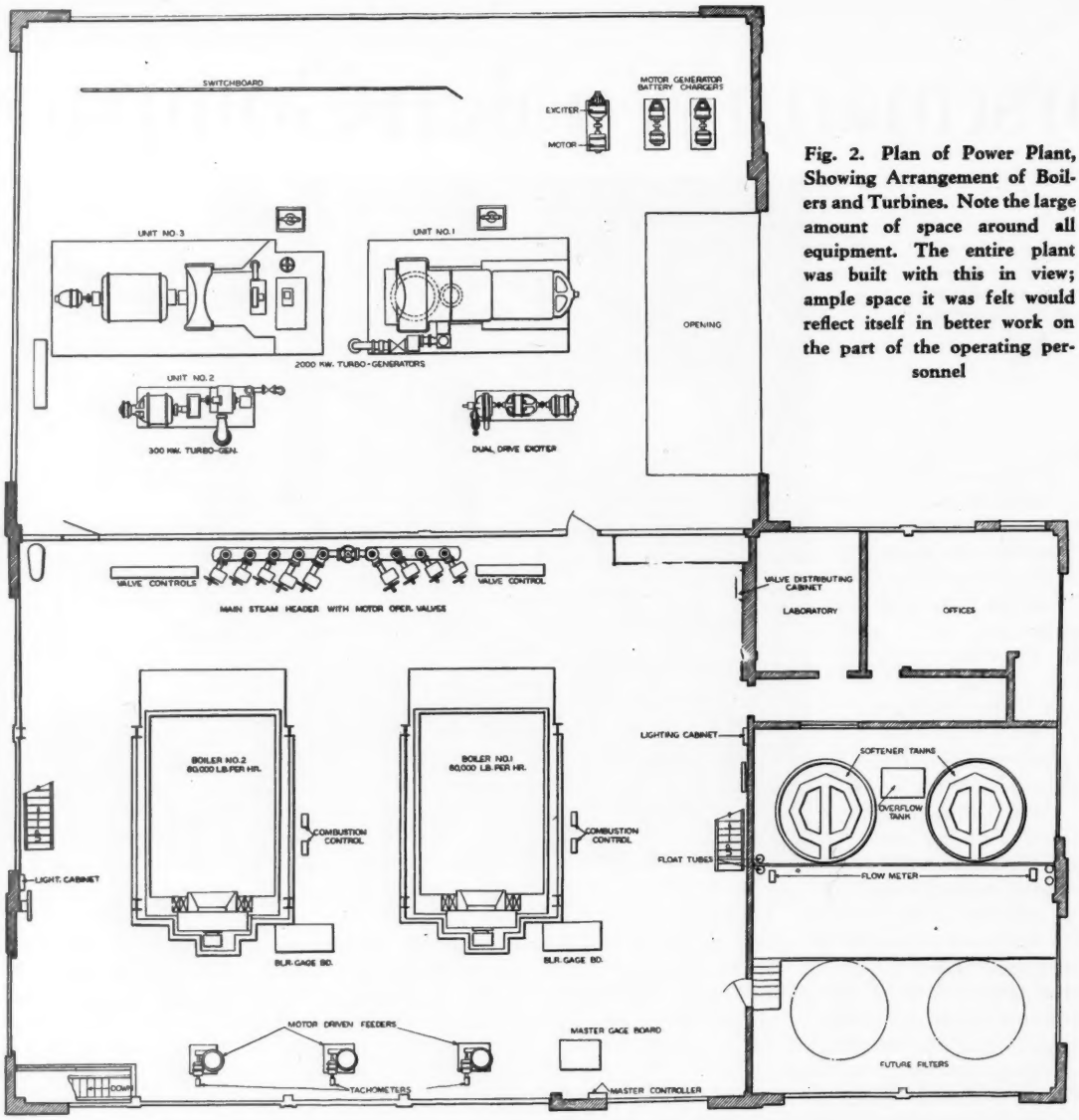



**Fig. 2. Plan of Power Plant, Showing Arrangement of Boilers and Turbines. Note the large amount of space around all equipment. The entire plant was built with this in view; ample space it was felt would reflect itself in better work on the part of the operating personnel**

ft. of heating surface. The steam entrance ends of the superheater tubes are rolled into the dry steam drum and extend over the entire length of this drum, thereby providing an even distribution of steam to the superheater tubes. Each boiler and superheater unit is provided with six soot blower units arranged for hand operation from the operating floor.

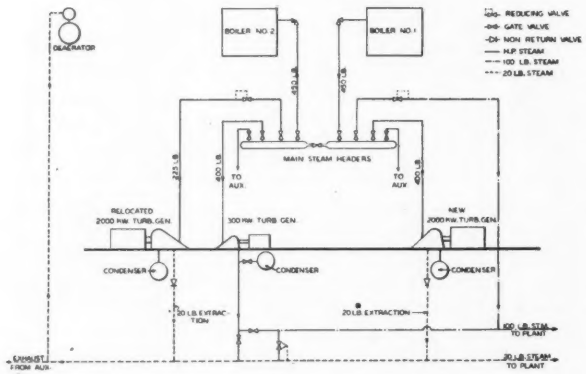



FIG. 3. FLOW DIAGRAM OF HIGH AND LOW PRESSURE STEAM SYSTEM

### Furnaces Are Water Cooled

Each boiler furnace has a volume of 4500 cu. ft. and is of the hopper bottom type, water cooled throughout with bare tubes, except for that portion of the side walls near the burners where refractory covering has been used to effect more efficient combustion conditions at lower ratings. Circulation of water is provided from the lower rear drum to water wall headers at the bottom of the side, front and rear walls for cooling purposes. The side and rear walls of the boiler setting are made up of 2-in. shiplap refractory tile backed up with 3 in. thick Superex block insulation, and the entire unit is totally enclosed with steel casing arranged in panels. The front wall is of similar construction, except that, instead of shiplap tile, there is a solid refractory wall backed up with Superex insulation and a steel casing as on the rest of the furnace.

Both the forced and induced draft fans are on a

# Principal Equipment, Garfield Power Plant

## BOILERS AND AUXILIARIES

**Boilers**—Riley Stoker Corp., two, bent-tube four drum water tube, three pass, 450 lb. pressure, 6520 sq. ft. heating surface; water walls front, rear and side 2290 sq. ft. total heating surface; water tube sloping front and rear floor 500 sq. ft. total heating surface; 80,000 lb. steam per hr. rated capacity, 4500 cu. ft. furnace volume.

**Superheaters**—Riley Stoker Corp., one per boiler, convection type located in first pass between boiler tubes, 530 sq. ft. heating surface, 610 deg. F. final steam temperature.

**Air Preheaters**—Riley Stoker Corp., one per boiler, single pass vertical tubular 6550 sq. ft. external heating surface, 538 deg. F. final air temperature.

**Safety Valves**—Crosby Steam Gage & Valve Co.

**Blowoff Valves**—Yarnall-Waring Co.

**Soot Blowers**—Diamond Power Specialty Corp.

**Water Columns**—Stets Co.

**Boiler Feedwater Regulators**—Stets Co., two per boiler.

**Boiler Feed Stop Valves and Check Valves**—Edward Valve & Mfg. Company, Inc.

**Boiler Non-Return Valves**—Edward Valve & Mfg. Company, Inc.

## FUEL HANDLING AND BURNING EQUIPMENT

**Drag Scraper Yard Storage**—Sauerman Bros., Inc., 1500 tons storage, 20 cu. ft. bucket.

**Track Hopper and 18-in. Wide Belt Conveyors**—Stephens-Adamson Mfg. Co., 50 tons per hr.

**Ring Roll Type Coal Crusher**—American Pulverizer Co.

**Coal Bunker and Spouts**—Stephens-Adamson Mfg. Co., 250 tons storage.

**Coal Automatic Weigh Scales**—Richardson Scale Co., total of three.

**Coal Feeders**—Riley Stoker Corp., total of three.

**Coal Pulverizers**—Riley Stoker Corp., three, unit type, one connected to each boiler, third one to either boiler, 5000 lb. per hr. each, 75 hp., 1150 r.p.m., General Electric steam turbine drive.

**Pulverized Coal Piping and Valves**—Riley Stoker Corp.

**Pulverized Coal Burners, Flare Type**—Riley Stoker Corp., one per boiler.

**Oil Burners**—Engineer Co., one per boiler, mechanical atomizing type.

**Oil Storage Tank**—Quaker City Iron Works, 10,000 gal.

**Oil Pump and Heater Unit, Steam and Motor Driven**—Engineer Co.

## DRAFT SYSTEM

**Forced Draft Fans**—Green Fuel Economizer Co., one per boiler, horizontal double inlet, each 28,500 c.f.m. at 7.7 in. static head, 60 hp., 1550 r.p.m., variable speed governed General Electric steam turbine drive.

**Induced Draft Fans**—Green Fuel Economizer Co., one per boiler, horizontal double inlet, each 55,000 c.f.m. at 7.2 in. static head, 120 hp., 1020 r.p.m., variable speed governed General Electric steam turbine drive.

**Flue Gas Scrubber**—Riley Stoker Corp., one per boiler, direct contact water washing type, six sections each.

**Stacks**—Riley Stoker Corp., one per boiler, self supporting steel, 80 ft. high, 6 ft. diameter.

**Steel Plate Air Ducts**—Riley Stoker Corp.

## ASH HANDLING AND SOOT REMOVAL EQUIPMENT

**Ash Hoppers**—Allen-Sherman-Hoff Co., one per boiler with hydraulic nozzles.

**Ash Sluice**—Allen-Sherman-Hoff Co., basement ash sump, ash sump pump, outside overhead dewatering and storage tank, ash sump pump discharge piping.

**Soot Removal Vacuum Transport System**—Allen-Sherman-Hoff Co., hydraulic ejector.

## FEED WATER EQUIPMENT

**Softeners**—Hungerford & Terry, Inc., two 10 ft., 6 inches high by 10 ft. diam. Zeolite water softeners, each 9000 g.p.h. average, 13,500 g.p.h. max.

**Flow Controllers and Recorders**—International Filter Co.

**Sodium Sulphate Feeding Equipment**—American Water Softener Co.

**Deaerator**—Elliott Co., one direct contact heating and storage type, 20 lb. pressure, 150,000 lb. per hr., 3000 gal. storage.

**Deaerator Level Control**—Ruggles-Klingemann Mfg. Co.

## TURBINE AND CONDENSER EQUIPMENT

**Turbine**—One 2000 kw., 3600 r.p.m. condensing automatic extraction at 20 lb. per sq. in. gage with 550 v. 3 phase, 60 cycle generator, direct connected exciter and surface type generator air cooler—General Electric Co.

**Turbine**—One 300 kw., 5054/1200 r.p.m. geared variable back pressure with 550 v. 3 phase, 60 cycle generator and direct connected exciter—General Electric Co.

**Turbine**—One relocated 2000 kw., 3600 r.p.m. condensing automatic extraction at 20 lb. per sq. in. gage with 550 v. 3 phase, 60 cycle generator and surface type generator air cooler—General Electric Co.

**Condensers for 2000 kw. Units**—Ingersoll Rand Co., two pass horizontal surface type 1290 sq. ft. each, external air coolers, steam jet air removal, surface type inter and after condensers, each unit with two 75 g.p.m., 1750 r.p.m., 5 hp. motor driven condensate pumps.

**Condenser for 300 kw. Unit**—Ingersoll Rand Co., two pass horizontal surface "Navy" type, 338 sq. ft., internal air cooler, steam jet air removal, surface type inter and after condensers, with two 23 g.p.m., 3450 r.p.m., one hp. motor driven condensate pumps.

**Circulating Water Pumps** — Ingersoll Rand Co., two 1725 g.p.m., 1150 r.p.m., 20 hp., 550 v., 3 phase, 60 cycle General Electric motor drive.

**Turbine Expansion Joints**—Griscom-Russell Co.

## PUMPS

**Boiler Feed Pumps**—Ingersoll Rand Co., two 200 g.p.m., 2050 r.p.m., 5 stage, 550 lb., each with General Electric variable speed governed 130 hp. turbine.

**Boiler Feed Pump**—Ingersoll Rand Co., one 300 g.p.m., 3545 r.p.m., 4 stage, 630 lb., with General Electric constant speed 200 hp. induction motor and Ruggles-Klingemann excess pressure discharge control valve.

**Raw Water Pumps**—Warren Steam Pump Co., Inc., two 350 g.p.m., 1750 r.p.m., 20 hp. Allis Chalmers motors.

**Deaerator Feed Pumps**—Warren Steam Pump Co., Inc., two 300 g.p.m., 1750 r.p.m., 20 hp. Allis Chalmers motors.

**Ash Sluicing Pump**—Warren Steam Pump Co., Inc., one 750 g.p.m., 2000 r.p.m., 85 hp. General Electric turbine.

**Back Wash Pump**—Warren Steam Pump Co., Inc., one 650 g.p.m., 1700 r.p.m., 15 hp. General Electric turbine.

**Drip Pumps**—Ingersoll Rand Co., two 25 g.p.m., 1750 r.p.m., 5 hp. Allis Chalmers motors.

**Oil Transfer Pump**—Viking Pump Co., one 75 g.p.m., 1725 r.p.m., 5 hp. Allis Chalmers motor.

**Sodium Sulphate Pump**—Westco Pump Corp., two 5 g.p.m., 1725 r.p.m., 2 hp. Allis Chalmers motors.

**Brine Pump**—Westco Pump Corp., one 25 g.p.m., 1725 r.p.m., 1½ hp. Allis Chalmers motor.

**Process Water Pumps**—Warren Steam Pump Co., Inc., two 100 g.p.m., 1725 r.p.m., 5 hp. Allis Chalmers motors.

## TANKS

**Soft Water Storage Tanks**—Pottstown Sotter Tank Works, Inc., two 13,500 gal. each.

**Raw Water Storage Tanks**—Pottstown Sotter Tank Works, Inc., two 13,500 gal. each.

**Raw Water Service Tank** — Pottstown Sotter Tank Works, Inc., 10,000 gal.

**Process Water Tank**—Pottstown Sotter Tank Works, Inc., 5500 gal.

**Blowoff Tank**—Pottstown Sotter Tank Works, Inc.

**Drip Receiver**—Pottstown Sotter Tank Works, Inc.

## INSTRUMENTS

**Boiler Meters**—Bailey Meter Co.

**CO and $CO_2$ Recorders and Indicators**—C. J. Tagliabue Mfg. Co.

**Multipoint Temperature Recorders**—Leeds & Northrup Co.

**Draft Gages**—Bailey Meter Co.

**Indicating Pressure Gages**—Crosby Steam Gage & Valve Co.

**Indicating Thermometers**—C. J. Tagliabue Mfg. Co.

**Flow Meters**—Bailey Meter Co.

**Level Indicators**—Bailey Meter Co.

**Mercury Column Vacuum Gages**—C. J. Tagliabue Mfg. Co.

**Recording Thermometers and Pressure Gages**—Bailey Meter Co.

## PIPE, FITTINGS AND VALVES

**High Pressure Piping**—M. W. Kellogg Co., Boiler Room.

**High Pressure Steam Pipe** — Midwest Piping & Supply Co., Inc., Turbine Room.

**Low Pressure Pipe**—Midwest Piping & Supply Co., Inc., Cornell & Underhill, M. W. Kellogg Co., Simmons Pipe Bending Works, E. F. Keating Pipe Bending & Supply Co.

**Scrubber Drain Pipe** — Johns-Manville Corp.

**Cast Steel Fittings** — Glover Machine Works.

**Cast Steel, Cast Iron and Bronze Valves**—Wm. Powell Co.

**Forged Steel Valves**—Consolidated Ashcroft Hancock Company, Incorporated.

**Forged Steel Check Valves** — Edward Valve & Mfg. Co., Inc.

**Reducing Valves** — Ruggles-Klingemann Mfg. Co.

**Relief Valves**—Atwood & Morrill Co., Cochrane Corp.

**Reverse Flow Valves**—Atwood & Morrill Co.

**Float Controlled Valves**—H. Belfield Co.

**Extraction Non-Return Valve**—Schutte & Koerting Co.

**Expansion Joints**—Croll-Reynolds Engineering Co.

**Traps**—Armstrong Machine Works.

**Valve Control**—Cutler-Hammer, Inc.

**Ric-Wil Conduit**—H. W. Porter & Co.

## SERVICE EQUIPMENT

**Combustion Control**—Leeds & Northrup Co., complete hand or automatic regulation of forced and induced draft fans, dampers, and coal feeders with interlocks and safety devices.

**Turbine Room Crane**—Whiting Corp., 20 ton, one motor.

**Turbine Oil Purification Equipment**—De Laval Separator Company.

**Dual Drive Exciter**—General Electric Co., 60 kw., 1800 r.p.m., 20 lb. back pressure turbine, 100 hp., 550 v., 3 phase, 60 cycle motor and 60 kw., 125 v. generator.

**Relocated Motor Driven Exciter**—General Electric Co., 40 hp., 550 v., 3 phase, 60 cycle motor with 25 kw., 125 v. generator.

**Vacuum Cleaning System**—Spencer Turbine Co.

**Unit Heaters**—B. F. Sturtevant Co.

## ELECTRICAL EQUIPMENT

**Main Switchboards and Switching Equipment**—General Electric Co.

**Storage Battery**—Electric Storage Battery Co., 60 cell, 160 amp. hr.

**Motor Generators**—Electric Products Co., two 15 hp., 1800 r.p.m. motors, 10 kw., 125 v. generator.

**Station Auxiliary Motor Starting Controls**—Cutler-Hammer, Inc.

**Power Distribution Cabinets**—Square D Company.

**Lighting Cabinets** — Bull Dog Electric Products Company.

**Lighting Fixtures** — Benjamin Electric Company.

## MISCELLANEOUS

**Heat Insulation**—H. W. Porter Co.

**Float Switches**—H. Belfield Co., Cutler-Hammer, Inc.

**Continuous Blowdown Flash Tank and Heat Exchanger**—Cochrane Corporation.

**General Air Cooler Ducts**—Connery & Co., Inc.

**Air Compressors** — Chicago Pneumatic Tool Co., two horizontal duplex, each 428 c.f.m., with intercooler, aftercooler, receiver and direct drive General Electric 100 hp., 300 r.p.m. synchronous motor.

fan floor above the boilers. This is not only the most logical arrangement, but also provides additional heat savings by utilizing the warm air which naturally collects at this point. Each boiler is provded with one forced and one induced draft fan and has an individual stack. Each forced draft fan has a capacity of 28,500 c.f.m. at 70 deg. F. against 7.7 in. water pressure and each induced draft fan a capacity of 55,000 c.f.m. at 350 deg. F. against 7.2 in. water pressure. Each fan is driven by a steam turbine with speed regulation from the combustion control equipment acting directly on the turbine governor valve. Both fans are equipped with damper control.

Air preheaters are vertical, single pass, tubular type heaters, located in back of the boilers and each having approximately 6550 sq. ft. of external heating surface. No soot blowers have been provided for this equipment. The flue gases after leaving the air preheater pass through a flue gas scrubber, also located on the fan floor, before entering the induced draft fan. Effective removal of fly ash from the flue gases is imperative in order to prevent damage in manufacturing processes as well as to prevent fly ash nuisance in the territory surrounding the plant. Careful analysis of the performance, economic features, and the operation and maintenance of equipment for this service prompted the choice of flue gas scrubbers consisting of a series of baffle plates over which a continuous film of water passes. These scrubbers remove the fly ash effectively and are easy to operate. The scrubber drainage is disposed of by ebony impregnated Transite pipe coated inside with asphalt. The joints in the scrubber drain lines are made by special "Dresser" type couplings.

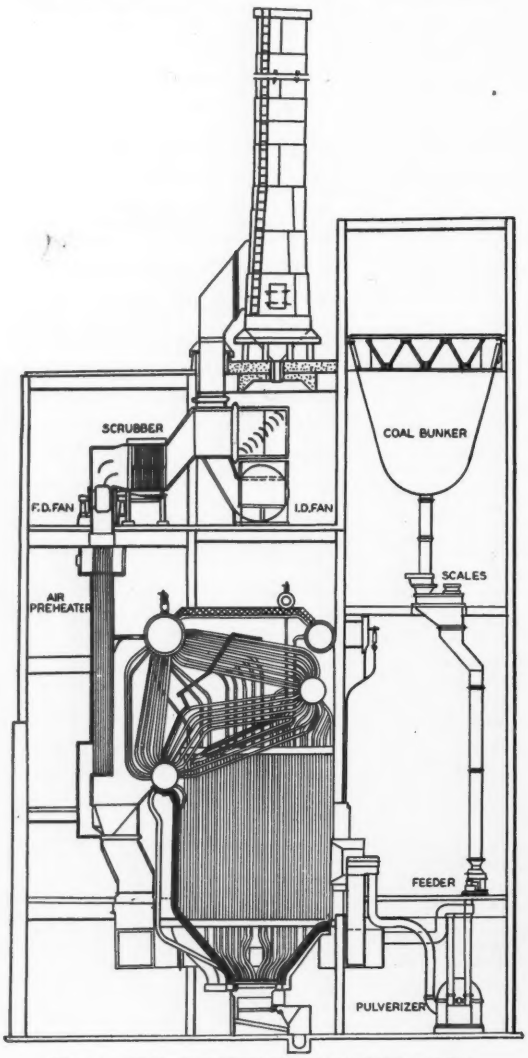



FIG. 4. CROSS SECTION OF BOILER ROOM

## Feedwater System

In deciding upon a proper feedwater supply it was necessary to consider that the makeup necessary might be as high as 75 or even 100 per cent according to process requirements. S. T. Powell, consulting engineer, of Baltimore, Md., made a detailed report covering water supply recommendations based on an extensive survey of the available water supply in the district serving the plant. The basic design of the water treatment system was developed by the engineers in collaboration with Mr. Powell from the data in this report. All make-up water is taken from the industrial supply of the Passaic Valley Water Commission after being treated by two gravity type Zeolite water softeners, each having a capacity between regenerations of 225,000 gal. The average rate of use per hour of each unit is approximately 9000 gal. with a maximum rate of 13,500 gal. per hr. The softened water is discharged directly to two steel storage tanks, each having a capacity of 13,500 gal. Space for future installation of additional softening and treating equipment has been provided in the water treating plant.

Before being delivered to the deaerator by two motor driven deaerator feed pumps, the boiler feed water passes through a continuous blowdown heat exchanger, where it is heated approximately 20 to 40 deg. F. The deaerator has sufficient capacity for deaerating 150,000 lb. of water per hr. with an inlet temperature of 50 deg. F. and an outlet temperature of 258 deg. F. when supplied with steam at 20 lb. per sq. in. gage. The deaerator delivers deaerated water to the boiler feedwater system with 0 cc. oxygen per litre. A tank with a working storage capacity of approximately 3000 gal. is provided with the deaerator.

Boiler feedwater is delivered normally to the boilers

FIG. 5. FORCED AND INDUCED DRAFT FANS, SHOWING AUTOMATIC CONTROL MECHANISM

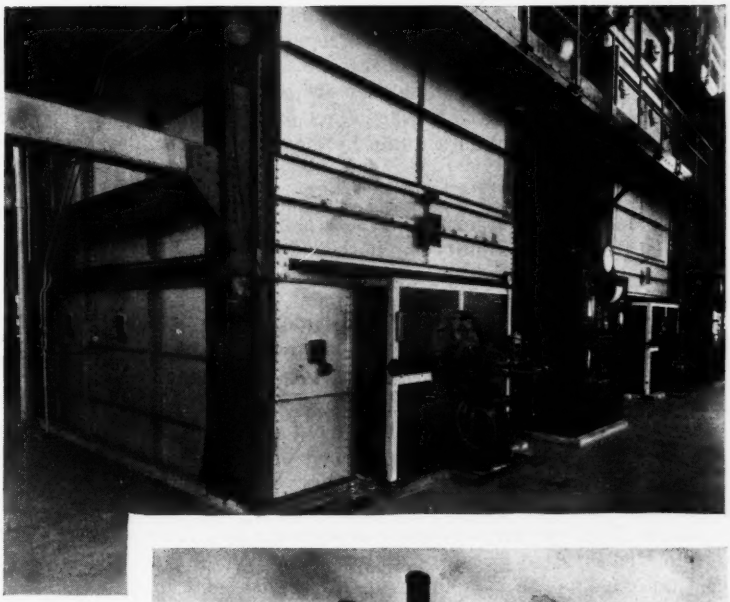
by one of three boiler feed pumps, of which two are turbine driven and one motor driven. Two Stets feed water level regulators are provided for each boiler, one feeding into each side. The differential pressure drop across these regulators is used to actuate either the valve control diaphragms on the turbine driven feed pumps for speed control or a regulator controlling a chronometer valve in the motor driven boiler feed pump discharge.

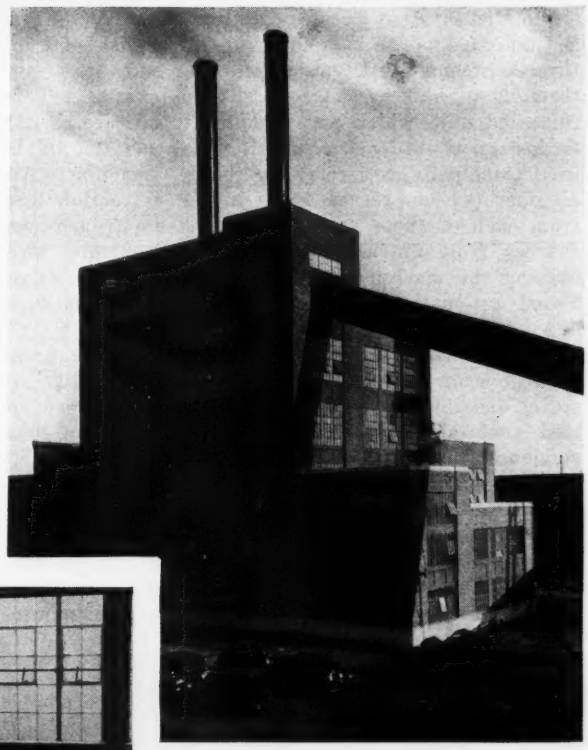
Two steel tanks of 13,500 gal. capacity each are also located in the basement of the water treating plant for service water and for ash sluicing and scrubber water requirements. Water for these services is taken from air-lift wells which were already in operation for other plant requirements. All cold water tanks have been coated internally with "Bitu-marine" enamel, and painted externally with "Nitrose."

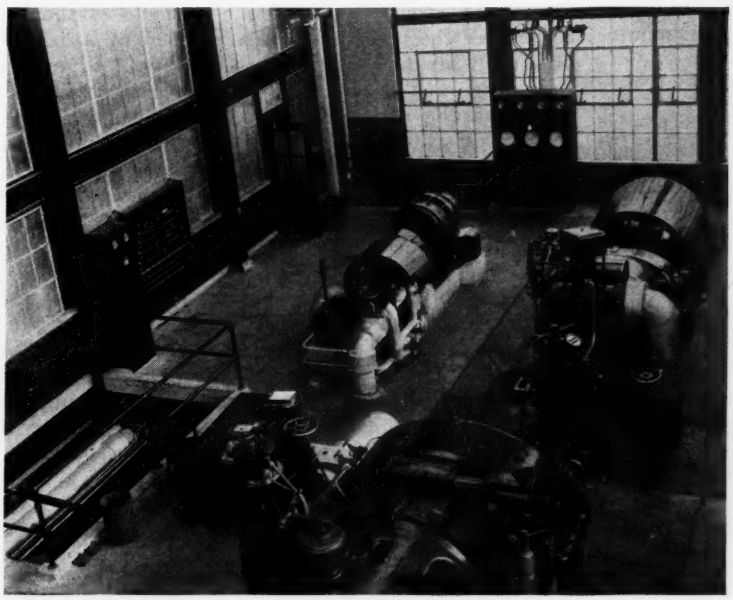
Extra heavy piping with Sargol type flanged joints has been used in all high pressure steam lines. With the exception of the high pressure steam and boiler feed piping, wherever economically advisable the pipe lines have been welded to eliminate flanged joints with their attendant possibilities of trouble. The use of creased or corrugated bends or of welding fittings to save space, and the use of corrugated piping or of Croll Reynolds expansion joints in the exhaust lines for expansion has been followed where ecnomically justified.

Boiler leads supply steam to two cross connected manifold type headers, from which the high pressure steam is distributed. The auxiliary steam and exhaust systems are of the sectionalized loop type so that steam for deaeration and the principal auxiliaries is always available.

Ashes and soot are disposed of by a sluicing system, designed to dispose of all ash and soot removed







**VIEWS AT THE GARFIELD PLANT *of the* FORSTMANN WOOLEN COMPANY**

**Top: The burners are fed from below, eliminating all piping in the firing aisle. Center: Exterior view. Note large amount of glass used. Lower left: The turbine room.**

from the furnace bottom, the stacks, and the last pass of the boiler. All of these wastes together with the drains from the flue gas scrubbers, are discharged to an ash settling pit from which they are pumped to an overhead dewatering and storage tank outside of the building and removed to a dump by means of trucks.

### Turbine Generators

Turbine room equipment was selected with special consideration for flexibility for both power and steam loads in order to allow the units to run at efficient ratings over the greatest possible portion of the year. Since the plant has no outside power tie-in, the equipment had to be installed with a 100 per cent power relay for each unit to insure against any mill shutdown. The turbine generator equipment consists of a new 2000-kw. extraction unit, an old 2000-kw. extraction unit which was reconditioned and relocated from the former engine room, and a new 300-kw. back pressure unit.

Both 2000-kw. units operate condensing and have automatic constant pressure extraction at 20 lb. per sq. in. gage. The new unit operates with 400 lb. throttle steam, but the relocated unit takes its steam through a reducing valve at 225 lb. pressure. This relocated unit, which was rebladed to operate at 225 lb. instead of its former throttle pressure of 150 lb., is used principally as a relay for the new machine. An oil operated non-return valve in the extraction line from each of these units prevents steam from other sources from entering the extraction opening and causing the machine to overspeed. This valve trips closed automatically as soon as the machine is shut down for any reason.

The 300-kw. unit normally operates with backpressure governing to exhaust directly into the 100 lb. steam distribution system. This unit is arranged so that it can also exhaust into the 20 lb. system or to a condenser, although, except for loads less than 150 kw., it is ordinarily more economical to run one of the 2000-kw. extraction machines for these conditions. However, on weekends when the mill is shut down and the load very light, it is often desirable to run the 300-kw. machine alone with speed governing and a 20 lb. exhaust in the winter, or condensing in the summer.

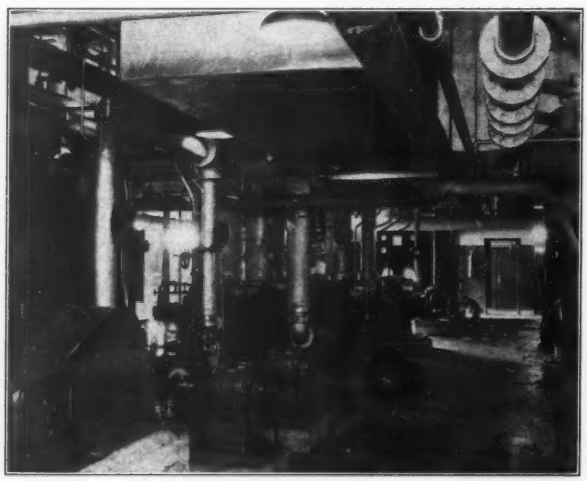


FIG. 7 VIEW IN BASEMENT SHOWING PUMPS AND PIPING

Each 2000-kw. unit is provided with a two pass surface condenser having approximately 1290 sq. ft. of condensing surface. The tubes are rolled into each tube sheet and relative expansion is taken care of by an expansion joint in the shell. The condenser shells are carried directly on the concrete turbine supports, expansion being taken care of by copper expansion joints between the turbine and the condenser. Air is removed from these units by two stage steam jets with surface type inter and after condensers. There are two condensate pumps for each condenser and two circulating water pumps for the entire plant.

The condenser for the 300-kw. unit is of the "Navy" type with internal air cooler, two stage steam jet air removal and surface type inter condenser and after condenser.

The boiler room is provided with a Leeds and Northrup electrical combustion control system arranged for hand or automatic operation of either one or both boilers. This equipment gives complete regulation of the forced and induced draft fan speeds and dampers, and controls the coal feeders. The control equipment is mounted on a master gage board at one end of the operating aisle and on the individual boards for each boiler.

Since the power house delivers steam, power and water to a number of departments of the plant, metering equipment is provided for charging out these quantities for production cost purposes as well as those required to serve as a guide to the operation of the power house equipment. In general, the metering system provides a complete check of the power house output against the input of coal and water.

Two air compressors, each of 428 c.f.m. actual delivery capacity, are installed in the basement of the power house to serve the compressed air requirements of the entire plant. The water treating system serves the entire plant.

### Electrical Features

Power is generated at 550 v., 3 phase, 60 cycles. The main bus and oil circuit breaker room is located underneath the turbine floor adjacent to the turbine foundation structure. Provision is made so that in the future the main bus can be divided by a bus tie oil circuit breaker with new 2000-kw. unit connected to one side and the other two units to the other side. Power to the manufacturing plant is controlled by solenoid operated oil circuit breakers and distributed to the various buildings through underground cables.

The power distribution system to the production departments was completely revamped to insure flexibility and dependability of power supply for manufacturing.

The main control switchboard consists of two exciter panels, a battery control panel, 3 generator panels, one voltage regulator panel, and panels to take care of 29 present or future feeders. The new units each have a direct connected exciter, while excitation for the relocated 2000-kw. unit is obtained from a 25-kw. motor driven exciter.

The design and construction of this plant was done under the supervision of the Engineering and Construction Dept. of the Forstmann Woolen Co. in collaboration with C. H. Schlachter and S. T. Powell as consultants.

# Calibration *of* Fans *and* Mill Exhausters

**Knowledge of the Fundamental Relation of Flow, Speed, Capacity and Power Consumption Shows How to Judge Operating Conditions. By P. B. Place**

FOR ANY GIVEN SPEED, the pressure drop across a fan or exhauster is a function of the flow. This function may be established and the results plotted in terms of pressure drop and speed so that the flow through the fan may be quickly determined at any time by measuring the speed of the fan, the pressure drop across the fan and the density of the flow. The method is particularly adaptable to pulverizing mill exhausters handling dusty air as it is at times difficult to measure accurately dusty air with a Pitot tube. The flow however may be established by test with clean air without the mill in operation and the plotted results used to determine the flow with dusty air.

Results of tests on an exhauster used in connection with a unit mill pulverizing coal are given as illustrative of the method. The air flow through the exhauster was measured at different speeds and different pressures with the exhauster handling only clean air, the pressure at each exhauster speed being varied by changing the position of the air inlet damper at the mill. Air flows were measured both before and after the exhauster with a standard Pitot tube. The line leading to the exhauster was 22 in. in diameter and the line from the exhauster was 14 in. in diameter.

With the mill in operation and the exhauster handling dusty air, further measurements of the air flow were made, but check readings are much more difficult to obtain with dusty air because the dust plugs part or all of the static pressure holes of the Pitot tube. Several sets of measurements were made and the results averaged to eliminate errors due to erratic readings. Density of the clean air flowing was determined by measuring the temperature of the air at the fan and the humidity of the air at the mill inlet. For the test case given, Fig. 1 shows the average density of the clean air at different temperatures at the fan. When milling coal, part of the air to the mill was preheated and so the temperature was somewhat higher than when air alone was circulated.

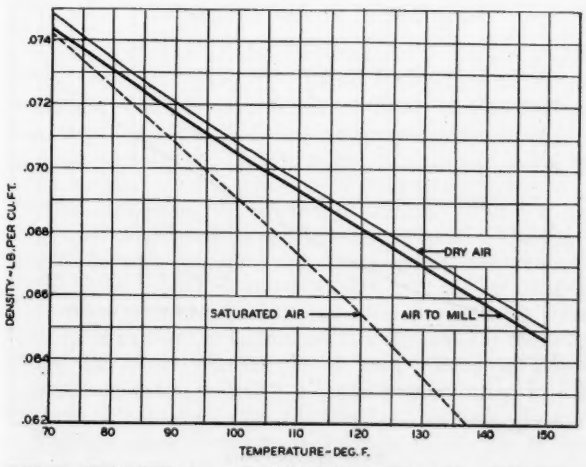



FIG. 1. DENSITY OF AIR VARIES WITH THE TEMPERATURE AND HUMIDITY

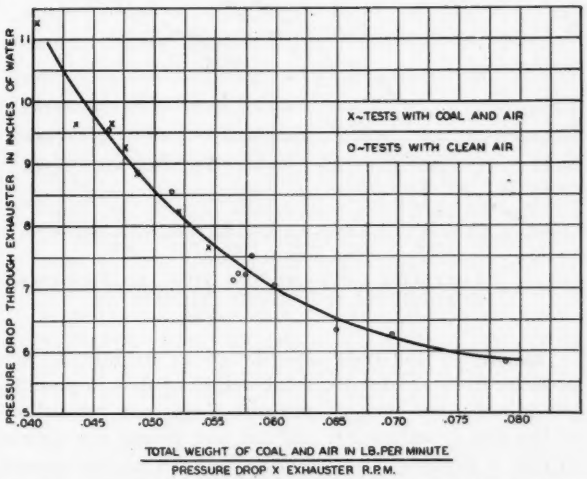



FIG. 2. CHARACTERISTIC CURVE CALCULATED FROM TESTS

### Density of Mixture

Density of the coal-air mixture handled when milling coal was calculated by adding the weight of the coal to the weight of the air to give the total weight of flow. Thus for example, if the density of the air was 0.065 lb. per cu. ft. and the flow was measured and found to be 5000 c.f.m. when the mill was milling coal at the rate of 3 t. per hr. the calculated density of the coal-air mixture is as follows:

$0.065 + [(3 \times 2000) \div (5000 \times 60)] = 0.085$ lb. per cu. ft.

The volume of the mixture is the volume of the air only, the volume of the solid coal being negligible. The weight of the coal, however, is a very appreciable pro-

portion of the density of the mixture as seen by the above calculation and the fan has to move this extra weight even though it has no appreciable volume.

### Correct Pressure Measurements Difficult to Make

The pressure drop across the exhauster was measured with a differential water-filled manometer connected to taps in the lines leading to and from the exhauster. These pressure taps must be carefully made to give as nearly as possible the true static pressure drop across the unit. Even when poorly located, the results will serve, comparatively for the particular fan tested but may not be applicable to other similar fans in the plant. In order that the tests on one fan may be used to determine the flow through other fans of the same design and size, the pressure taps must be located similarly on each unit and be free from burrs and other irregularities that might affect the static pressure readings.

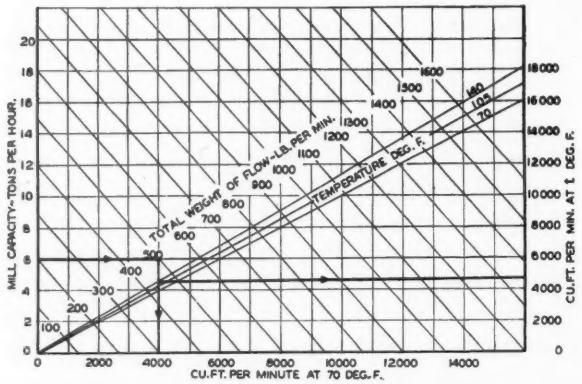



FIG. 3. CHART FOR DETERMINING THE AIR AND COAL PROPORTIONS FOR GIVEN CONDITIONS

Results of the tests are plotted as in Fig. 2, the pressure drop against the total weight of flow in pounds per minute, per inch of pressure drop, per revolution of the fan or exhauster. Actual test points are shown in Fig. 2 to show the agreement between measurements taken with clean air and those obtained when pulverizing coal.

The use of the curve is as follows: If the pressure drop across the fan is 7.0 in., the flow per inch per revolution is 0.060 lb. per min. so if the speed of the fan is 1100 r.p.m. the total flow is $0.060 \times 7.0 \times 1100 = 462$ lb. per min. or 13.86 t. per hr. If clean air is being handled at 80 deg. F. its density from Fig. 1 is 0.073 lb. per cu. ft. and the volume handled is $462 \div 0.073 = 6330$ c.f.m. If, however, the mill is pulverizing coal at the rate of 3 t. per hr. and the temperature of the air is 125 deg. F. the density of the air alone will be 0.0675 lb. per cu. ft. and the volume handled will be $[462 - (3 \times 2000 \div 60)] \div 0.0675 = 5363$ c.f.m. so the density of the coal-air mixture is $462 \div 5363 = 0.081$ lb. per cu. ft.

Having determined the total flow in pounds per minute, the flow in cubic feet may be found from Fig. 3. For example, if the total weight of flow is found to be 500 lb. per min. and the mill is pulverizing at the rate of 6 t. per hr. with the temperature of the coal-air mixture 140 deg. F., the flow at 70 and 140 deg. F. is 4000 and 4800 c.f.m. respectively.

If it is more convenient to measure the volume of the coal-air mixture than to determine the rate of milling, the same calibration may be used to determine mill capacity. Several sets of Pitot measurements should be made and averaged to eliminate erratic readings due to plugging of the Pitot tube static holes. Thus for example, if the volume of the mixture is found to be 5000 c.f.m. at 125 deg. F. a fan speed of 1150 r.p.m. and a pressure drop across the fan of 7.0 in., the total weight of flow as determined from Fig. 2 is 483 lb. per min. The density of the air at 125 deg. F. is found from Fig. 1 to be 0.0675 lb. per cu. ft. The mill capacity, W, is then calculated as follows:

$$[483 - (W \times 2000 \div 60)] \div 0.0675 = 5000$$
$$W = 4.3 \text{ t. per hr.}$$

Power requirements of a fan or exhauster is a function of the speed as shown by the results plotted in Fig. 4. Here also the total weight of flow is the weight of air or of coal and air and the power may be conveniently expressed in terms of kilowatt hours per ton of total flow. If only clean air is circulated the flow is tons of air but if coal or other dust is being handled the total flow is tons of air plus tons of coal per hour.

### Example Illustrates Use of Charts

Figure 4 may be used in conjunction with Fig. 2 to determine the power used. The total weight of flow is determined from Fig. 2 in pounds per minute and calculated to tons per hour by multiplying by $(60 \div 2000)$ or 0.03. Thus for a pressure drop of 9.0 in. and a speed of 1050 r.p.m. the total flow is 17.01 t. per hr., and from Fig. 4 the power at 1050 r.p.m. is 0.65 kw-hr. per t. or a total of 11.1 kw-hr. If the mill is pulverizing coal of 3 t. per hr. the power is $11.1 \div 3 = 3.7$ kw-hr. per t. of coal.

The above test method is not offered in preference to direct measurement of air flow, mill capacity and power consumption but as a means of assembling such direct measurements so that similar information may be quickly and easily determined for any rating at any time.

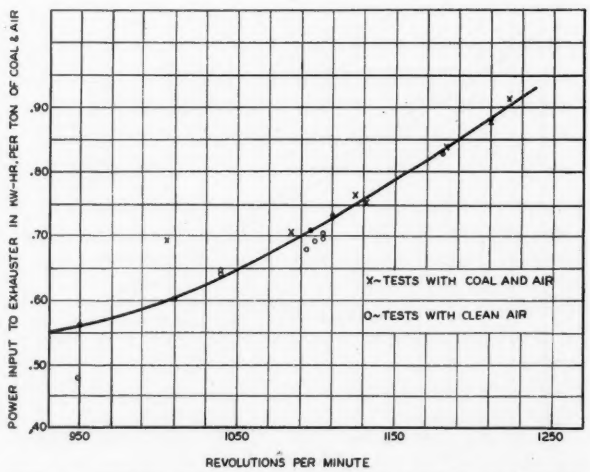
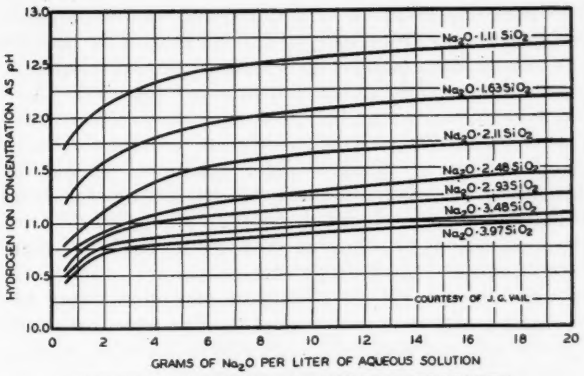

POWER INPUT TO EXHAUSTER IN KW-HR. PER TON OF COAL & AIR
REVOLUTIONS PER MINUTE
X-TESTS WITH COAL AND AIR
O-TESTS WITH CLEAN AIR

FIG. 4. CURVE SHOWING THE UNIT POWER CONSUMPTION AS A FUNCTION OF THE SPEED

# Silicon *in* *Boiler Waters*

**Water in Many Streams of Western Oregon is Soft in Terms of Usual Impurities but Contain Quantities of Silicon That Yield Hard Scale. By R. E. Summers and C. S. Keevil**




SOLUBILITY CURVES OF SODIUM SILICATES

USE OF THE TERM hardness as synonymous with a statement of the tendency of water to form boiler scale has largely obscured consideration of siliceous incrustations. Engineering literature of this country contains only casual mention of the probability and danger of siliceous scales. These facts led the authors, both of whom are on the faculty of the Oregon State College, to study the characteristics of this impurity in water and present their findings in a paper before the American Society of Mechanical Engineers, a summary of which is given here.

In certain geographic regions, notably western Oregon, conditions are suitable for the occurrence of natural waters high in silicate impurity. This impurity is thought to arise directly from volcanic rocks at the time of their decomposition and to appear at headward positions in surface streams flowing through regions of profuse rainfall and vegetation. In the river waters of western Oregon, siliceous impurities, expressed as $SiO_2$ approximate 25 to 40 per cent of the total anhydrous residue, roughly four times the average for North America. These same waters contain very little conventional hardness and are generally regarded as of excellent quality; yet the absolute siliceous matter content is fully as high as that of other typically bad waters characterized as carbonate, sulphate, chloride or nitrate waters. Such waters are therefore properly described as silicate waters.

### Siliceous Matter in Solution

In the face of the long standing dispute regarding the form taken by silicon compounds in natural waters, whether as colloidal $SiO_2$ or as dissolved silicates, it is contended that siliceous matter does often occur in solution. The entrance of colloidal silica into boiler scale is regarded as of no great importance in most instances. Allocation of silicon to an ion as a means to a better ionic balance in water analysis is considered a powerful argument against acceptance of the usual report of colloidal $SiO_2$. A review of literature on the analysis of silicon bearing natural waters show that leading experimenters throughout the world largely concur in the belief that silicon in potable water is not colloidal but is truly in solution in some form. Probable forms are $Na_4Sio_4$, $Na_2SiO_3$, $Na_2Si_2O_3$ and the corresponding compounds of calcium or magnesium.

Presence of siliceous matter as a major constituent of boiler scales is indicated by analyses of incrustations from western Oregon boilers. Analyses show the silicon contents of scales to range from approximately 25 to 60 per cent, expressed as $SiO_2$. That range of composition agrees with observation recently reported abroad. Presence of sodium in the scales is noted, further illustrating the possibility of other than the hardness forming elements in boiler scales.

### Cementing Agent of Boiler Scales

Formulation of boiler scales containing a high percentage of natural siliceous matter as a cementing agent is conceived to take place in several possible ways. The deposit of $SiO_2$ as pure quartz is not regarded as likely, although experiments are reported in which true rock crystal was formed from siliceous solutions at temperatures and pressures not greatly above those encountered in modern steam generators. The direct breakdown of sodium silicates to liberate $SO_2$ is seen as a mechanism not thought to be usual in boiler operation. Silicon as a silicate of an alkaline-earth metal or of iron or aluminum, appears to be the cementing agent in siliceous scales.

When water of considerable or predominate silicon content must be used for make-up in boiler plant, the prevention of siliceous scale deposit depends on (a) elimination of siliceous matters from the water before use, (b) removal of siliceous matter from the boiler water as non-adherent sludge, or (c) maintenance of siliceous matter in solution within the boiler.

(a) Silica in gross suspension, as turbid matter, can be largely eliminated by pretreatment. Little success has, however, followed attempts to remove dissolved siliceous matter. With very soft water chemical pretreatment is usually regarded as superfluous, yet those same softer waters tend to be the more silicate bearing. Treatment of water with flocculating material, sodium aluminate, and the like, appears to achieve doubtful silicate removal. Partial removal of silicates by lime-soda water treatment is regarded as an indirect action.

(b) The precipitation of silicates directly within a boiler is even less desirable than external removal, because of the danger of foaming, priming, excessive blow down, and boiler metal destruction.

(c) Retention of siliceous matter in solution in

boiler water appears to offer the best possibility at present. By addition of sodium, and by maintenance of pH values from 10.5 to 11.0 or 11.5, it is possible to render silica soluble in water at concentrations far greater than those demanded in boiler practice. Since, in boilers, there may be opportunity for siliceous matter to unite in part with calcium or magnesium, a high degree of freedom from hardness-forming elements is necessary. Even with all these precautions siliceous deposits might develop as a gel formed from concentrations of solute at evaporating surfaces where water circulation is sluggish.

Sodium phosphate treatment of boiler water has several features to recommend it. The phosphate salts of calcium and magnesium are highly insoluble in alkaline solution in the presence of excess phosphate. Sodium from the reagent contributes to the solubility of siliceous matter. The high pH values of the less acid phosphates, such as trisodium phosphate, further insure maximum silicate solubility. Calcium and magnesium precipitates formed with phosphates have the added advantage of carrying with them a considerable amount of silica from boiler water. The writers have found 15 per cent $SiO_2$ in such a precipitate. As much as 40 to 80 per cent has been reported.

Some practices to be observed as working rules for the control of siliceous scales are: (a) Hardness-forming matter is to be at a minimum in boiler water. Conventional water treatments should be used with reservation and with a knowledge of their limitations. (b) A high degree of silicate solubility is to be maintained through high boiler-water pH values and adequate sodium concentrations. Both of these are to be tolerated only when metal embrittlement protection is sure. The need for precaution is particularly great when natural waters are low in sulphate. (c) Even partial elimination of siliceous matter from boiler water is highly desirable.

# Increasing Boiler Pressure 300 Per Cent

**Conversion of a 140 lb. Boiler for 500 lb. Operation Described in Sulzer Technical Review**

AN ARTIFICIAL SILK factory recently converted a 140 lb. per sq. in. steam power station to a 500 lb. plant by rebuilding two boilers and adding a new engine. The old plant consisted of two Sulzer steam engines each with a battery of three Sulzer flue-tube boilers. One battery supplied steam at a pressure of 170 lb. per sq. in., the other at 140 lb. per sq. in.

Exhaust steam from the engines ranged from 7 to 11 lb. per sq. in. but the amount was too small to meet the demands for manufacturing purposes and a large part of the steam had to be supplied through reducing valves. Electricity generated was far from sufficient to meet the requirements and a further supply had to be purchased.

Investigations and calculations, made with a view to improving conditions, showed that an increase in the output of the engines would effect savings in the cost of electric energy of about Fr. 60,000 (about $19,000 at present exchange rates) per annum and that the cost of converting the plant could be written off in about 3 yr.

One of the existing engines was replaced by a new and larger unit working at a higher steam pressure

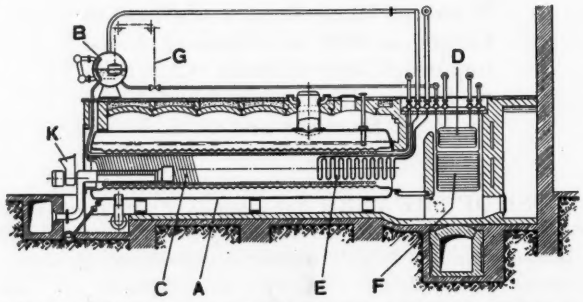



FIG. 1. SULZER-LA MONT 680 SQ. FT. HEATING SURFACE 500 LB., 750 DEG. F. HIGH PRESSURE BOILER FITTED IN A CORNISH BOILER

A. Cornish boiler; B, boiler drum; C, main evaporating tubes; D, superheater; E, supplementary evaporating tubes; F, economizer; G, feed-water regulator; K, underfeed stoker.

and two of the existing boilers were equipped with a La Mont tube system and underfeed stokers. They raise steam at 500 lb. per sq. in., 750 deg. F. The La Mont evaporating tubes were installed partly in the form of coils in the flues, and partly directly behind the flues of the boilers. Constructional changes made to the existing plant were insignificant.

Steam raised by the new boiler plant at 500 lb., 750 deg. F., ranges from 7500 lb. per hr. normally to 9700 lb. per hr. maximum with an efficiency of about 86 per cent. Initial conditions at the engine are about 425 lb., 710 deg. F., the back pressure 11 lb. per sq. in. abs. and the output 350 kw.

Exhaust steam is discharged wholly or partly into the existing heating piping. If required, a part of it is led back into the large water spaces of the converted boilers, which now work at a pressure of only 11 lb. per sq. in. It is also possible to supply the engine, if necessary, with steam from the 170-lb. boiler battery at a corresponding reduction in output.

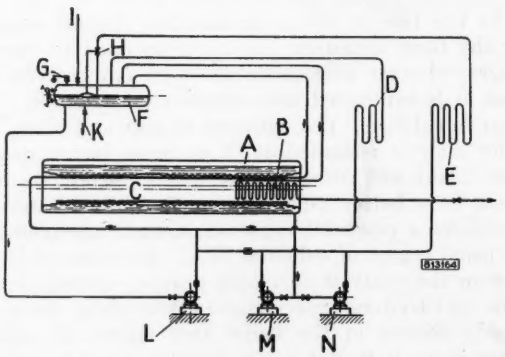



FIG. 2. DIAGRAMMATIC ARRANGEMENT OF THE TWO BOILERS

A, existing storage boiler; B, superheater; C, evaporating tubes; D, supplementary evaporating tubes; E, economizer; F, steam water drum; G, safety valve; H, feed-water regulator; I, blow-off pipe; K, drain pipe; L, circulating pump; M, feed pump: N, stand-by pump.

# *Fundamentals of Power Plant* Piping Design

**Part II. Carefully prepared drawings of power plant piping eliminate misunderstandings with contractors, permit proper and most efficient location of auxiliary as well as main equipment and forestall many expensive, last minute changes found necessary as work progresses.**

By

Henry C. Moffett*

MECHANICAL DESIGNING of piping systems today differs from such designing several years ago, since today this work consists principally in making layouts by choosing the locations of lines and branches, together with the proper placing of bends, fittings and specialties. None of these component parts are actually designed by the detailing draftsman, except those non-standard parts such as special fittings, valves and regulators that cannot be purchased from fabricators and specialty manufacturers as listed in their catalogs and bulletins. In most cases, even when such special parts are required, the manufacturers are better fitted to design these specials because of their knowledge of shop practice and shop limitations. Hence, the laying out of all but very special piping systems is the intelligent drawing together of known standards and purchasable valves and specialties, and is not a detailed design of each of the component parts.

### Main Steam Lines Most Important

As soon as all preliminary considerations are settled, as far as can be, and the pressures and temperatures have been decided upon, layout drawings should be started on such parts of the system for which sufficient information is at hand. Such drawings should be prepared in the order of their importance, selecting those parts to lay out first, the materials for which will require the longest time to manufacture or fabricate.

In modern steam power plants, the main steam lines are first in importance, and also usually take precedence as to location. It is therefore good practice to start the design of these lines first, and to follow these closely with designs for the boiler feed piping. All other lines, unless such large diameter pipes, as for instance are required in atmospheric exhaust lines, may be held until these lines are well along, and most details settled and their locations definitely decided upon. The valves and fittings for all high pressure steam and boiler feed lines, as well as most of the specialties, especially if the pressures are above 250 lb. per sq. in., must be made to order, as not many of these will be found in stock.

New designs and developments in regulatory devices have appeared these last few years, many of which are less troublesome and more sensitive than any offered before. Boiler feed regulators, steam pressure regulators, reducing valves, automatic draining systems and a host of other mechanisms and meters, when properly chosen and wisely installed, insure greater safety of operation and higher efficiencies in plant cycles, than if all operations are left to the whims of the operators. The manufacturers of these instruments and specialties have, by the clever use of the newer alloys, and the new application of primary principles, been able to produce simpler and more dependable devices, in which the multiplicity of springs and levers have been displaced by rugged diaphragms and pilot valves.

Valves and regulators, of one kind or another, are required in every line of piping. Gate valves for full open or closed operation, globe valves for throttling, check valves for preventing reversal of flow, back-pressure valves for maintaining a constant or nearly constant back-pressure, pressure reducing valves, safety valves, non-return valves and many others must each be carefully considered and their proper positions and functions known and stated. Every engineering concern engaged in steam power plant design is beseiged by representatives of the manufacturers of these devices, and a wise choice is difficult unless the engineer is experienced or inquires thoroughly into the details and is not influenced entirely by first costs.

As soon, however, as preliminary approvals are obtained on steam and boiler feed layouts, valve and specialty lists should be made and checked, quotations obtained, specifications for each compared, and orders placed.

### Design Guides

Piping layouts cannot be completed until all main equipment to which these lines must be connected, is on order and certified prints received from the manufacturers. Piping designers, before completing piping layouts, should check over all such certified prints to make sure that the bolting and flanged facings, as well as the opening sizes for pipe connections, are correct, or as called for. Early attention to these points will save a great deal of time later, and prevent serious alterations both in the plans and in the field work.

Several things must be kept in mind in laying out a line or system of piping. In the order of their importance these may be listed as:

The type of fluid to be transported by a pipe line, determines the kind of materials that must be used for

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1. Fluid to be conveyed, and quantity per unit of time.
2. Pressure of the fluid.
3. Temperature of the fluid.
4. Pressure drop that may be allowed between points.
5. Temperature drop that may be allowed between points.
6. Clearances.
7. Drainage.
8. Supports.
9. Coverings.

all parts of the line in contact with that fluid. In steam lines, except for low pressure or exhaust lines, steel must be used, unless the temperature is below 450 deg. F., in which case the fittings may be of cast iron.

Pipe sizes are functions of the quantity and quality of the fluid to be conveyed. Due to the decreased volume of steam at higher pressures, smaller lines may be used for the same temperatures. There are several formulas for the flow of steam in pipes, the best of which have been reduced to chart form for easy use and published in handbooks. These charts show the drop in pressure which will take place in 100 or 1000 ft. of pipe of various sizes and thicknesses, for saturated and superheated steam in a wide range of pressures and temperatures. The flow of water, air or gas in pipes is likewise reduced to simple graph form, so that a piping designer need only scale off the known quantities or functions, and find the unknowns with very little trouble. These charts are accurate enough for all practical purposes, and should be used wherever possible, as otherwise long calculations would consume a great deal of time and rarely be of any greater utility. All such charts should be kept in loose leaf form along with the tables of standards and other design aids in constant use.

In order to make sure that clearances are obtained, building foundation drawings and steel framing designs must be carefully examined whenever a pipe line is to be laid out in the neighborhood of such work. Scaled dimensions from these drawings may be very misleading, as they are quite frequently out of scale. In a complicated design, it is good practice to make a master set of drawings, both in plan and elevation, carefully drawn to scale, showing the possible obstructions. Over this may be superimposed all piping designs, which will immediately show the main clearance spaces.

At times, the steel and concrete designs are being prepared concurrently, and final drawings are not available. This is not an unfortunate condition, however, for in some cases it becomes necessary to shift equipment and alter building steel framing to accommodate large and important pipe lines.

It is also found to be true that supports for such lines must be designed in detail, and in conjunction with the steel framework of the building, or it may be found necessary to insert extra members or larger sections from which to hang heavy lines.

Regardless of the kind of line to be laid out, it should always be kept in mind that all parts may at some time have to be drained, either of water or condensate in the case of steam, air or gas lines, or the entire line emptied for inspection and repairs if carrying water. Drainage systems or drip lines for steam piping require careful designing, and should always be laid out for the system to be drained. Drips, if pure, and if the water returned to the boilers is evaporated, should be saved and put back into the make-up. Drips are handled in many ways, but most frequently are piped to some central point, such as a tank or reservoir, and pumped back into some line returning to the boilers.

Pipe insulation is a study by itself. Insulation is for two main purposes, first to prevent heat loss and the resultant condensation in steam lines, and second to prevent sweating or condensation on the outside of cold water lines located in humid galleries. As far as the laying out of such lines is concerned, the only consideration is that the addition of such covering increases the diameters of pipes, hence ample clearance must be calculated, and provision made for repairs to damaged insulation.

Companies manufacturing pipe coverings and heat insulation materials will furnish all tables and data required to determine the thicknesses necessary to accomplish a desired result.

Piping layouts should always be ample in size to show clearly the entire piping system considered to a scale large enough to make all required details stand out. If some important part must be shown in great detail, a separate drawing should be made and referenced to the layout in plan or section.

Figures and lettering should be large and distinct, and the outlines of the pipes drawn in bolder lines than the reference lines and equipment outlines.

It has been the practice of some engineers and architects to indicate piping layouts in a crude sketchy manner, leaving a large amount of the detailing to be worked out by the estimating contractor before he could put in an intelligent bid on the work. This leads to discrepancies, since no two contractors will then bid on exactly the same things. In like manner, some sets of specifications have been extremely meager or ambiguous, or so involved that no one could possibly tell just what was intended.

### Design Drawings

This practice has crept into the profession due to keen competitive bidding for the engineering work. It is not an efficient procedure, for it is always more economical to know in advance exactly what the layouts and specifications were intended to indicate. Clear neat drawings and concise specifications will always secure the best prices, as they eliminate the element of doubt from the minds of the bidders for which they must amply allow or run the chance of loss.

All notes and descriptions on drawings should be complete. All existing lines should be clearly distinguished from new work. Center lines must always be referenced to existing column centers or established base lines. All plans should have the north point clearly shown for orientation.

Many an otherwise good design has been poorly executed because of the lack of definite instructions or detailed information on drawings or in the specifications. The best designer leaves out all non-essentials, but never overlooks the necessity of absolute clarity throughout.

# *REHEAT*—— Practice, Operation *and* Control

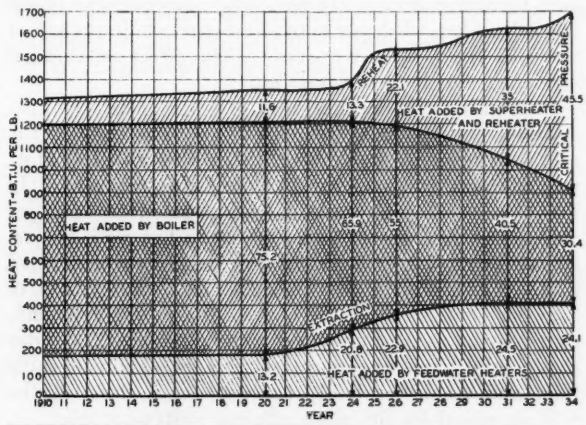



**Fig. 1. Chart showing the decreasing importance of the boiler surface as a heat absorber**

**INCREASED Importance of Superheating and Reheating Surfaces with Higher Temperatures and Pressures ¶ Probable Future Trend of Reheat Boiler Design.**

CONSIDERATION of the increasing importance of superheating and reheating surfaces with higher pressures and temperatures brings up the controversial and highly speculative matter of future boiler design. In a typical plant even today as much as a third of the total boiler work is accounted for by the superheater and reheater so that the importance of these elements must not be underestimated.

With other combinations of equipment already available these proportions could be reversed leaving only about a third of the total heat to be absorbed by the steam making surface. For steam generation at the critical pressure, initial superheat 850 deg., reheat at 300 lb. to 1000 deg. F. and extraction feedwater heating at 600 lb., about 800 B.t.u. would be absorbed by the superheater and reheater and only about 450 B.t.u. by the boiler itself. Of these 900 B.t.u. about half are required by the superheater.

These changing conditions were of course brought about by the use of higher pressures and temperatures and changes in practical cycles. Up to about 400 lb. pressure the total heat content per pound of saturated steam increases, after this it decreases as shown by Fig. 2. The total heat content of steam at 1400 lb. is but 94.5 per cent of what it is at 400 lb. while at the critical pressure of 3226 lb. the ratio drops to 74.5 per cent. Not only has the heat content of the saturated steam dropped but higher temperatures have increased the importance of the superheater and higher feedwater temperatures have robbed the boiler at the bottom of the cycle.

Up to about 1920, pressures and temperatures gradually increased, the boiler surface in an up to date plant absorbing perhaps 75 per cent of the total heat. The introduction of extraction heaters about this time increased the feedwater temperatures. Steam temperatures also increased rapidly so that by 1924 perhaps 66 per cent of the total heat in the steam was absorbed in the boiler. Introduction of reheat and still higher feed temperatures reduced the boiler work to about 55 per cent of the total by 1926. Since that time actual plant construction has not changed the ratio appreciably yet a number of isolated developments, such as critical pressure boilers, 1000 deg. F. total temperature and reheat taken together in a hypothetical plant might well reduce the work of the boiler proper to about 30 per cent as shown at the right of Fig. 1.

Variations in the heat absorption with different pressures and temperatures are shown more in detail by Figs. 3 and 4. Heat absorbed by various parts are

| | | |
|---|---|---|
| Economizer | 233 B.t.u. | 18.3 per cent |
| Boiler | 633 B.t.u. | 49.7 per cent |
| Boiler and Economizer | 866 B.t.u. | 68.0 per cent |
| Superheater | 231 B.t.u. | 18.1 per cent |
| Reheater | 177 B.t.u. | 13.9 per cent |
| Total | 1274 B.t.u. | 100.0 per cent |

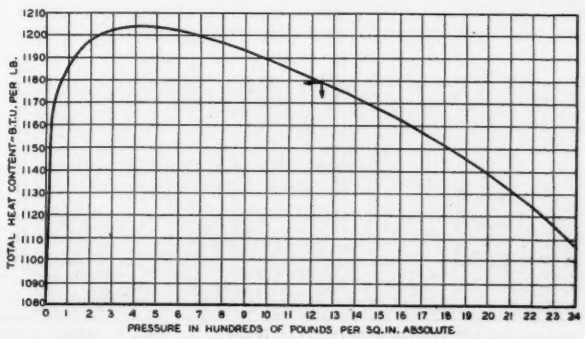



FIG. 2. VARIATION OF TOTAL HEAT WITH PRESSURE

With the boiler pressure increased to 3226 lb., initial superheat at the superheater outlet (2500 lb.) 850 deg. F., reheat at 400 lb. to 1000 deg. F. and feedwater heated in the crossover heater from 352 to 440 deg. F., heat absorption in the steam generator would be as shown by Fig. 4. It is divided as follows:

| | | |
|---|---|---|
| Economizer and Boiler.... | 566 B.t.u. | 41.6 per cent |
| Superheater ..... | 484 B.t.u. | 35.6 per cent |
| Reheater ..... | 310 B.t.u. | 22.8 per cent |
| Total .....1360 | B.t.u. | 100.0 per cent |

Economizer and boiler have been put together because at this pressure the latent heat of steam is zero and if a steaming economizer were used, the boiler surface would simply be a superheater.

A steam reheater added to Fig. 4 would change conditions as shown by Fig. 5. It is obvious that its only function is to transfer heat from one section of the unit to the other and that the same result would be obtained by additional reheater surface. Such an arrangement would eliminate the circulating heat load of 142 B.t.u. on the boiler. Inasmuch as the latent heat of steam at 3226 lb. is zero, the higher pressure steam to the reheater is throttled through valve A to 1500 lb. (saturation temperature 596 deg. F.) and the low pressure steam is reheated to 570 deg. F. in the steam section. A total of 0.231 lb. of saturated steam is required with a heat flow of 213 B.t.u. of which 71 B.t.u. is absorbed by the low pressure steam and 142 B.t.u. is returned in the condensate. This condensate could be pumped back to the boiler as shown by Fig. 5 or drained to one of the low heaters where it displaces some bleed steam. Distribution of the heat absorbed would be as follows:

| | | |
|---|---|---|
| Boiler and Economizer.... | 637 B.t.u. | 46.8 per cent |
| Superheater ..... | 484 B.t.u. | 35.6 per cent |
| Reheater ..... | 239 B.t.u. | 17.6 per cent |
| Total .....1360 | B.t.u. | 100.0 per cent |

**Total heat absorption has not been changed by adding the steam reheater but the proportion absorbed by the boiler surface has increased by the amount lost by the reheater, i.e., 71 B.t.u.**

### Change in Thermal Efficiency

Draining the reheater to the No. 1 extraction heater instead of pumping back to the boiler as shown by Fig. 5 would cut the amount of steam bled to the No. 1 heater by about 50 per cent. The net result would be to reduce the work done by the high pressure turbine 8 B.t.u. (516 per cent); increase the boiler work 18 B.t.u. (2.82 per cent) and increase the reheater work 71 B.t.u. (22.8 per cent). The effect on thermal efficiency will be mentioned later.

Assuming a boiler efficiency of 80 per cent, the heat supplied to the boiler in Fig. 3 would be 1580 B.t.u. and as the work done by the turbines is 518 B.t.u., the thermal efficiency would be 32.8 per cent. In Fig. 4 the efficiency would be increased to 34.3 per cent. It would be the same in Fig. 5 but with the reheater drained to the extraction heater as mentioned in the paragraph above the efficiency would drop to 33.9 per cent, although of course, the power consumption for the drain pump would be eliminated. Under these conditions of operation this is a considerable item and would probably account for a third of the 8 B.t.u. saved by the more efficient system.

This inevitable subjugation of the boiler to the superheater is bound to bring about radical changes in design. What these changes may be is difficult to predict although it would appear that the trend will be toward radiant steam cooled surfaces rather than toward water cooled furnace walls and convection superheater and reheater surfaces.

This is predicted not only on the superior operating characteristics of the radiant elements which meets turbine operation demands and simplifies the temperature control problem, but by actual heat absorption requirements of the various surfaces as pressures and temperatures increase and the impracticability of getting sufficient water cooled surface to enclose the necessary furnace.

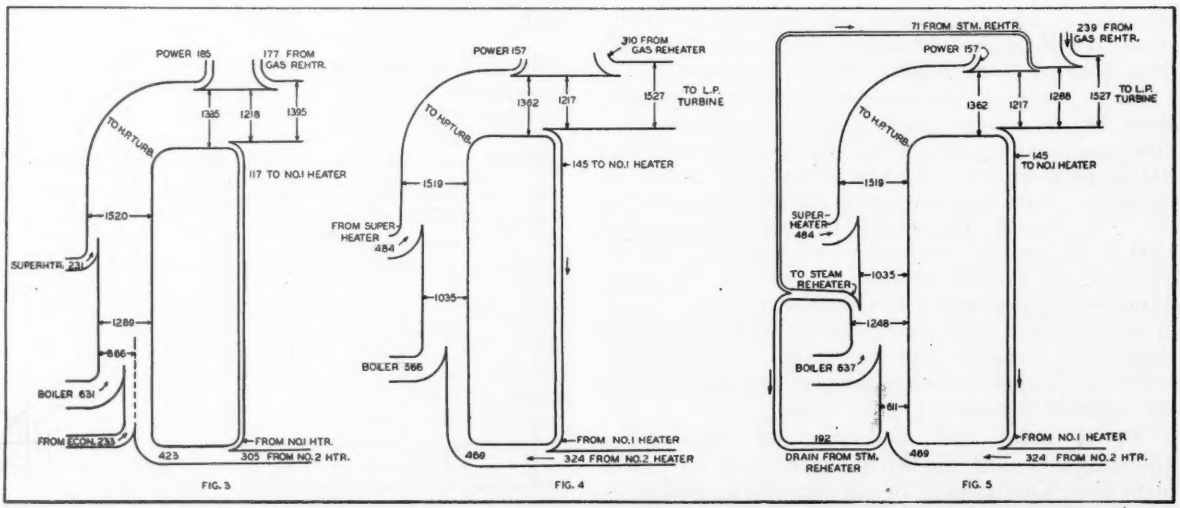



FIG. 3. HEAT ABSORPTION DIAGRAM IN A 1400 LB. REHEAT BOILER

FIG. 4. HEAT ABSORPTION DIAGRAM IN A 3200 LB. REHEAT BOILER

FIG. 5. CRITICAL PRESSURE BOILER WITH STEAM REHEATER ADDED

# HYDRAULIC TURBINE *for* Gas-Charged Water

AN UNUSUAL hydroelectric generating unit was supplied recently by the English Electric Co., Ltd., of Stafford, England, to the Imperial Chemical Industries for installation in South Africa where it is now in successful operation.

This unit which is described in the February 23, 1934, number of "Engineering" of London is unique in that it is designed for a water supply of 477 g.p.m., under a head of 1700 to 1870 ft., the water containing in solution from 6 to 10 times its own volume of gas at normal temperature and pressure.[1] The turbine had to be capable of extracting the energy from this supply and of discharging the mixture of gas and fluid to a height of 67 ft.

### Nozzle Converts Pressure to Velocity Energy So Rapidly Gas Cannot Escape

Because of the high head involved, it was necessary to use an impulse type of turbine. This, however, involved the difficulty that as the water passes through the nozzle, pressure usually falls at the mouth so that the gas would be liberated and the water turned into spray with the result that no useful work could be performed on the wheel. As a result of a theoretical consideration of this problem and a considerable amount of experimental work carried out by the Imperial Chemical Industries at their Bellingham works, shapes were developed for the nozzle and buckets which overcame this trouble, the pressure energy in the jet being converted into velocity energy and mechanical power so rapidly that the gas has not time to come out of solution.

Figures 1 and 2 which are photographs of the jet issuing from the nozzles of this machine show how successfully the nozzle problem was solved. Figure 1 shows a jet of the gas charged water under the operating head and Fig. 2 a corresponding jet of pure water for comparative purposes. As will be seen it is difficult to distinguish one from the other.

### Casing Maintained Under a Pressure to Discharge Water

The requirements with regard to discharging against a head of 67 ft. were met by maintaining the turbine casing under pressure, arranging for the upper part always to be filled with gas, which serves as a cushion to force the discharge to the height required. The wheel runs at 1000 r.p.m., and is of the overhung type. An alternator with enclosed slip rings was provided to insure flame-proof conditions. The turbine casing was made of cast steel, in order to withstand the internal pressure, and as this might fluctuate considerably from the nature of the chemical process involved, a test pressure of 70 lb. per sq. in. was applied to the casing, and an emergency bursting plate is provided in the top of the cone, fitted with an exhaust pipe.

The runner for this machine is provided with stamped instead of cast buckets, with the object of insuring perfectly homogeneous material to withstand the action of the gas-charged water. The bucket splitter edges have been very carefully formed and the buckets have been given a high polish. They are shaped to conform to the results of the special investigations referred to above. They are attached to the wheel disc by a single-bolt fastening, in which a single slightly coned bolt is used in conjunction with a split bush, alternate buckets bearing on shoulders integral with the disc and on driven-in taper keys.

### No Governor Except Emergency Trip Used

Where the shaft passes through the casing it is provided with a stainless-steel sleeve and runs in a water-cooled pressure gland. The nozzle and hand-operated spear are also of stainless steel. Axial guide vanes maintain a good jet. No governor is required, as the discharge remains practically constant, but an overspeed trip is provided to guard against emergency. This trip consists of an unbalanced ring on the shaft, held in place by a spring, until the centrifugal force developed by overspeed overcomes the spring and allows the ring to project far enough to engage a trigger. The latter operates a trip valve which brings into operation a deflector directing the jet from the wheel.

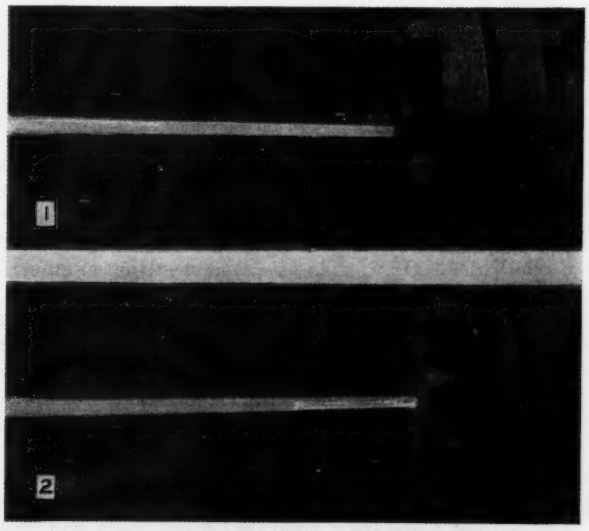



FIG. 1. JET OF WATER CONTAINING DISSOLVED GAS.
FIG. 2. JET OF GAS FREE WATER.

[1]This gas charged water apparently is the result of one of the chemical processes in this plant, probably some sort of a scrubbing processes accomplished under high pressure.

POWER PLANT ENGINEERING May 1934

# Wyandotte, Michigan *Expands* POWER FACILITIES

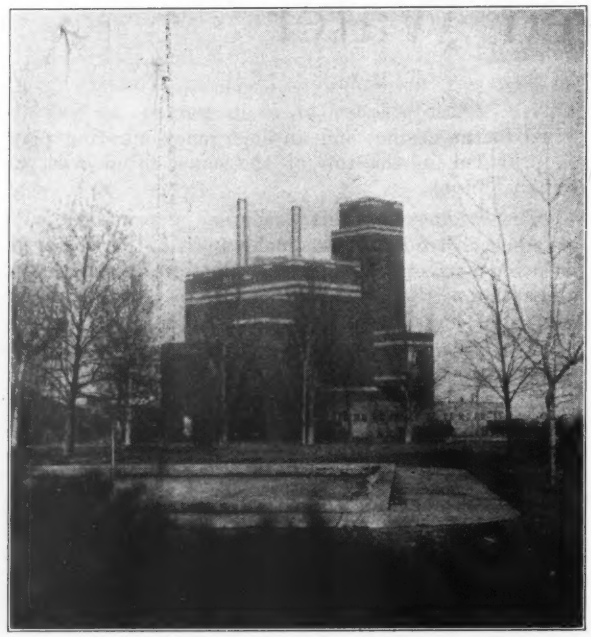


FIG. 1. EXTERIOR OF THE NEW PLANT LOOKING TOWARD THE RIVER

**THIS is an interesting account of how one of the oldest municipal systems in the country successfully solved what seemed at first an insurmountable difficulty. ¶ Confronted with the question of meeting increased load demands but with money that had been set aside for a new plant tied up in emergency city financing they revised their plans and solved the difficulty in an unusual way**

RECENTLY the city of Wyandotte, Mich., operating one of the oldest municipal electric systems in the country, completed the first unit of a 10,000 kw. power plant. From a modest beginning, starting from a $12,000 bond issue voted in 1892, the system has grown until the equity is over $1,270,000 with a gross revenue, averaged over the last six years, of over $400,000 annually. In the main, expansions have been financed from earnings and of the small bond issues voted from time to time only $17,000, due in 1937, remains. The new plant was also financed out of earnings and of the $544,512.43 invested all but $12,731 has been paid, a portion of this being witheld pending satisfactory performance of contracts.

By 1928 the electric load was increasing at the rate of 18 per cent per year and major extensions became necessary. In order to take advantage of modern efficient equipment a proposal to rebuild the old plant for $280,000 was turned down and a new plant decided upon. In 1930 The Froehlich & Emery Engineering Co. of Toledo, O., was retained as consulting engineers to design the new plant with an ultimate capacity of 10,000 kw. Originally separate boiler and turbine rooms were planned but the tax situation in 1932 made it desirable to alter the plans considerably. The Municipal Service Commission loaned $141,287 to the city on short term notes, expecting the money to be returned after the tax collection period.

This could not be done and the power plant plans were changed. The boiler room was completed as planned but plans for a separate turbine room and new turbo-generators were abandoned. An existing turbine was rebuilt for higher pressure and installed in the boiler room between the boilers as shown by Fig. 2. This change was made practical by an agreement signed in 1930 with the Michigan Alkali Co. whereby the city purchased current up to 6000 kw. at a very favorable rate of $0.011 per kw-hr. from the latter company. This agreement enables the city to eliminate standby equipment and to operate its own unit at a load factor of 80 per cent or over. The two power plants of the company and the power plant of the city give three reliable sources of power and practically eliminate the possibility of power failures.

### Building and Foundation

Foundation piles, averaging about 55 ft., are driven to bed rock and are capped with 6 ft. concrete matte upon which the plant is constructed. The building itself is 70 ft. wide, 90 ft. long, 104 ft. high at the greatest elevation and has a volume of 612,750 cu. ft. The land upon which it is built was reclaimed, largely by clay from sewer and other excavations. This reclaimed area extends to the harbor line of the Detroit River, insuring an ample supply of condensing water and a convenient coal dock at which the fuel may be delivered directly to the plant storage system by self unloading barges.

Coal handling equipment consists of a track hopper, 75 t. per hr. drag scraper, 50 t. per hr. skip hoist, 60 t. per hr. crusher on top of the bunkers and a shuttle conveyor over the bunkers provided for each boiler. Coal fed by gravity from the 120 t. bunkers is weighed by automatic scales before delivery to the stoker hoppers.

The drag scraper used for storing or reclaiming coal and for delivering it from the dock to the skip hoist hopper is operated from a glassed-in balcony over the track hopper and visible in Fig. 1 at the extreme right of the tower. Coal received by rail is delivered directly to the skip hoist pit.

The boiler room has two 620 hp., 450 lb., 700 deg. F. Combustion bent tube boilers fired by Taylor stokers. Each boiler has a tubular air heater, motor driven forced and induced draft fans and cinder traps. Furnaces have water cooled side and bridge walls, the former consisting of seven rows of tubes above the grates covered with cast-iron blocks. Above this is a 9 in. refractory wall. Furnaces are equipped with double roll clinker grinders. Ash from the hoppers is sluiced into a concrete pit, pumped to an overhead ash bunker and loaded by gravity on dump trucks or railroad cars. Soot and dust from the soot hoppers and cinder traps are also discharged to this hopper by means of a vacuum system.

Boilers are designed for 250 per cent rating, the forced draft fans, driven by slip ring motors with 13 pt. pilot drum control, have a capacity of 22,500 c.f.m. at 9 in. and the induced draft fans, driven by two speed full voltage induction motors, have a capacity of 44,500 c.f.m. of 600 deg. F. gas at 6 in. Feedwater regulators and complete combustion control are provided. The compact design and automatic control enable two operators per shift (6 hr. at the present time) to handle the plant.

Two boiler feed pumps are installed, one driven by a 150-hp., 440-v. motor and the other by a 150-hp. turbine. They also have two general service pumps, pumping water from the river intake to the general service system and two heater pumps pumping from the surge tank to the deaerator, in each case, one of the pumps being driven by a motor and the other by a turbine.

Heating steam for a nearby hospital and five other municipal buildings is supplied by two industrial evaporators. There are also two double effect evaporators for supplying make-up with a high level condenser between the boiler feed pumps and boilers. The heating units are operated as single effect evaporators to supply 125 lb. heating steam. These are hooked up so that any unit can be used for any service. No chemical treatment is used but a deaerating feedwater heater is used and eventually two stages of extraction heaters will be used in the cycle.

### Turbine

The turbo generator is a 2500 kv.a., 2300 v. unit rebuilt for the higher pressure and temperature, the reconstructed machine having a capacity of 3000 kv.a. and a 14 per cent increase in efficiency. Circulating water is taken direct from the Detroit River, through a twin strainer, by a 3800 g.p.m. centrifugal pump driven by a 40 hp. motor. The single generating unit is made practical by the interconnection with the two power houses of the Michigan Alkali Co. as mentioned earlier.

Two 25-kw. exciter units are installed, one motor driven, the other dual drive. The main switchboard consists of four cubicle type panels with oil circuit breakers. Underground lead covered cables connect the main switchboard with the Vinewood substation built in 1930. The house service switchboard is also of this type, using carbon circuit breakers and house service at 440 v. is supplied by a bank of 150 kv.a. transformers. Bus bars connecting the transformer bank to the house service switchboard are placed in steel busway enclosures.

The unique feature of the plant is, of course, the location of the turbine in the boiler room, thus saving a considerable amount of steam piping and the construction of a turbine room, giving an estimated sav-

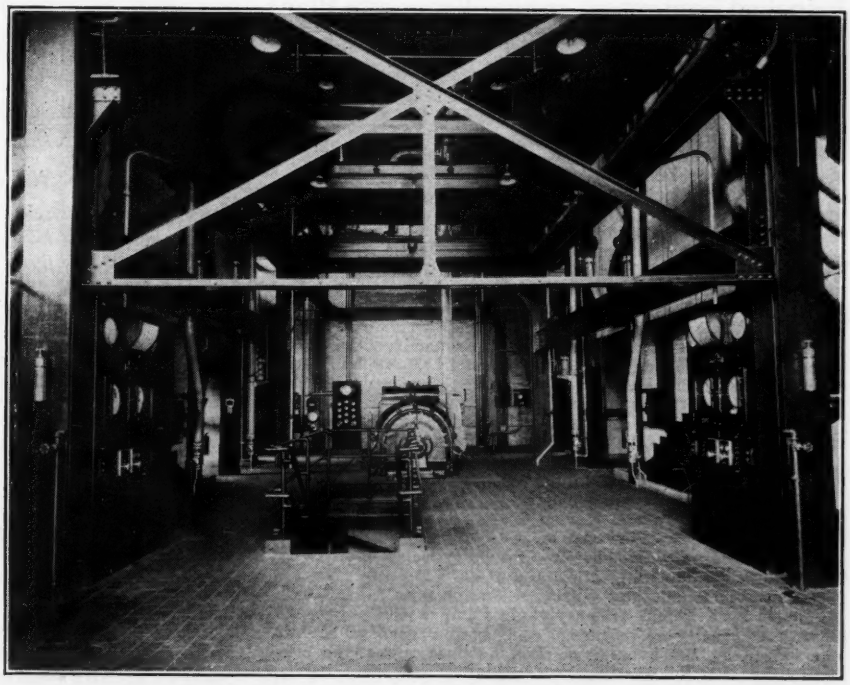


Fig. 2. Interior showing the turbine located between the two boilers.

TABLE I. GENERAL DISTRIBUTION OF POWER PLANT COST

| | |
|---|---|
| Building, foundation, piling, coal bunker, water tunnels, hopper and cinder pits and plumbing | $160,900.82 |
| Boilers, air heaters, furnaces and accessories | 87,241.25 |
| Stokers | 20,650.00 |
| Coal handling equipment including drag line scraper, skip hoist, crusher and scales | 28,078.00 |
| Ash and soot handling system | 33,540.00 |
| Forced and induced draft fans | 12,794.58 |
| Cinder collectors | 8,281.42 |
| Stacks | 2,950.12 |
| Rebuilding turbine | 14,282.45 |
| Boiler feed pumps | 9,485.00 |
| Evaporators, heaters and surge tank | 12,819.00 |
| Exciters | 1,751.55 |
| Transformers, switchboard and electrical work | 37,249.32 |
| Miscellaneous (including engineering) | 114,488.92 |
| Total | $544,512.43 |

ing of $75,000. This saving appreciably lowered the unit cost of the first section which even yet is high due to the installation of the coal handling, ash handling and circulating water tunnels of sufficient capacity to take care of the ultimate capacity of 10,000 kw.

In 1926 the citizens of Wyandotte adopted a new charter which created a Municipal Service Commission of five members, one appointment and one retirement taking place each year. At the present time this commission consists of C. A. Brethren, W. L. Cahalan, W. D. Le Bar, A. Milne, C. F. Schroeder, R. R. Wiesinger. H. E Allen is general superintendent of the department and C. F. Bufe is chief engineer of the new plant.

## Principal Equipment in the Wyandotte Plant

**Service**—Municipal Electric System.
**Engineers**—The Froehlich & Emery Engineering Co.
**General Contractor**—H. G. Christman, Burke Co.
**Boilers**—Combustion Engineering Co., Inc., 2, 620 hp., 450 lb., 4 drum bent tube boilers.
**Superheater**—Superheater Co., designed to give 700 deg. F. total steam temperature at 200 per cent rating.
**Air Heater**—Combustion Engineering Co., Inc., 2, tubular type.
**Water Walls**—American Engineering Co.
**Stokers**—American Engineering Co., 2, with a projected grate area of 135 sq. ft. each and double roll clinker grinders.
**Forced Draft Fans**—Green Fuel Economizer Co., 2, with a capacity of 22,500 c.f.m. at 9 in., each driven by 50 hp., 440 v. General Electric motor.
**Induced Draft Fans**—Green Fuel Economizer Co., 44,500 c.f.m. at 6 in., 600 deg. F., each driven by 75/40 hp., 440 v. General Electric motor.
**Cinder Catchers**—Green Fuel Economizer Co.
**Stacks**—Green Fuel Economizer Co., 2, self-supporting 5 ft. diameter steel stacks, 210 ft. above grade.
**Boiler Safety Valves**—Crosby Steam Gage & Valve Co.
**Stop Valves and Check Valves**—Edward Valve & Mfg. Co.
**Water Columns**—Yarnall-Waring Co.
**Gage Glasses**—Yarnall-Waring Co.
**Blow-Off Valves**—Yarnall-Waring Co.
**Soot Blowers**—Diamond Power Specialty Corp.
**Combustion Control**—Bailey Meter Co.
**Feedwater Regulators**—Northern Equipment Co.
**Boiler Feed Pumps**—Pennsylvania Pump & Compressor Co., 2, with a capacity of 125 g.p.m. each against head of 1250 ft., one driven by 150 hp., 440 v. Westinghouse motor, the other by 150 hp., 400 lb. Westinghouse turbine.
**Deaerating Heater**—Cochrane Corp.
**Surge Tank**—Cochrane Corp.
**Evaporators**—Griscom-Russell Co., 6, 4 high pressure for 125 lb. heating system; 2 double effect for boiler make up.
**Heater Pumps**—Pennsylvania Pump & Compressor Co., 2 with a capacity of 250 g.p.m. against head of 125 ft., one driven by 15 hp., 440 v. Westinghouse motor, the other by 15 hp. Elliott turbine.
**General Service Pumps**—Pennsylvania Pump & Compressor Co., 2 with capacity of 500 g.p.m. against 150 ft. head, one driven by 30 hp., 440 v. Westinghouse motor, the other by a 30 hp. Elliott turbine.
**Drag Scraper**—Sauerman Bros., capacity 75 t. per hr.
**Skip Hoist**—Link Belt Co., fully automatic, capacity 50 t. per hr.
**Coal Crusher**—Link Belt Co., Double roll, 60 t. per hr.
**Distributing Conveyor**—Link Belt Co.
**Coal Scales**—Richardson Scale Co.
**Coal Distributors**—Roland Gardner Co.
**Coal, Ash and Soot Handling System**—Allen-Sherman-Hoff Co.
**Valves** (2 in. and over)—Wm. Powell Co.
**Valves** (under 2 in.)—Edward Valve & Mfg. Co.
**Insulation**—Johns-Manville Co.
**Grating**—Universal Mfg. Co.
**Steam Piping**—Johnson Larsen Co.
**Circulating Water Piping**—Johnson Larsen Co.
**Turbo-Generator**—Westinghouse Elec. & Mfg. Co., 3000 kv.a., 2300 v., designed for 450 lb., 750 deg. steam.
**Condenser**—Westinghouse Elec. & Mfg. Co.
**Steam Jet Vacuum Pump**—Westinghouse Elec. & Mfg. Co.
**Hot Well Pump**—Westinghouse Elec. & Mfg. Co.
**Circulating Pump**—Westinghouse Elec. & Mfg. Co.
**Twin Strainer**—Elliott Co.
**Exciters**—Westinghouse Elec. & Mfg. Co., 2, 25 kw., 120 v., d.c., one driven by 30 hp. 440 v. motor, the other dual drive, 30 hp. motor and 30 hp. turbine.
**Main Switchboard Cubicles**—Roller-Smith Co.
**House Service Cubicles**—Trumbull Elec. & Mfg. Co.
**House Service Transformers**—Maloney Electric Co., 150 kv.a. single phase 2300/440 v.
**Flow Meter**—Bailey Meter Co.

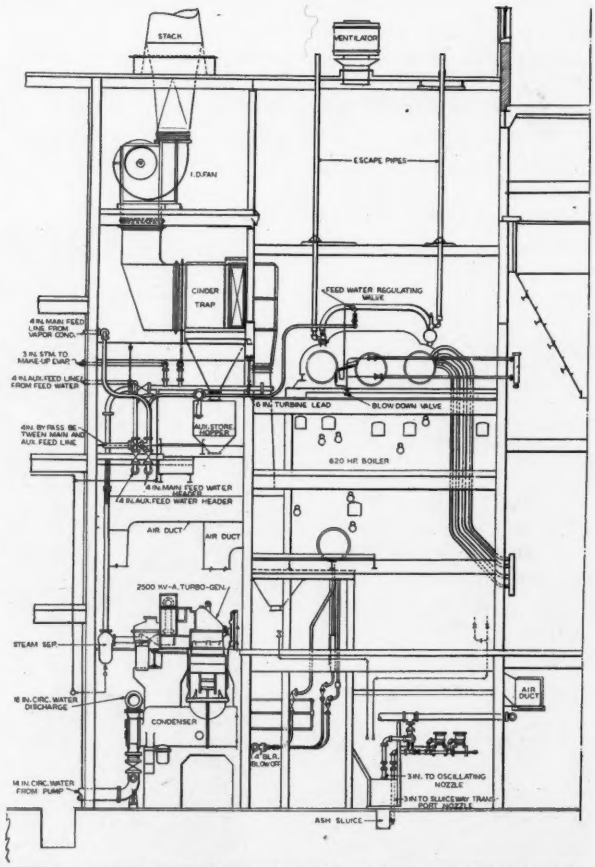



FIG. 3 CROSS SECTION OF THE PLANT. EVAPORATORS ARE IN THE BAY AT THE LEFT

# Check Your Overspeed Trip

**The Good Operator Does Not Tempt Providence by Waiting for an Accident to Tell Whether the Emergency Stop Operates Properly. By J. H. Pound**

SOME MEN fasten down the safety valves of boilers; some men tie circuit breakers shut; and some men operate steam turbines with the over-speed stop out of service. Which of these men is the biggest risk to himself and his neighbors is a matter of small importance; maladjustment of each of these safeguards is a practice sufficiently dangerous to warrant its being both preached against and penalized by severe discipline. It is true that in some cases the guilty man is punished by his own act, but usually the property damage and often the loss of life falls on entirely innocent parties. The proper remedy for such risks is, of course, their prevention by an appreciation of the dangers involved.

In the case of the automatic turbine stop, most manufacturers regularly supply the over-speed protection in addition to the usual constant-speed governor for much the same reasons that two safety-valves, set at slightly different pressures, are recommended for steam boilers. Unfortunately, the manufacturer cannot force the operator to give this protective device the simple care it requires, and too often this neglect results in a ruptured disc similar to the one in Fig. 1. In this case, the operator was lucky. His attempt to run a 400 hp., 3600 r.p.m. impulse turbine with its over-speed stop out of service resulted only in the loss of one machine and no lives. Many times such failures damage neighboring equipment, as well as injuring men by high-speed fragments or by scalding.

Need for an over-speed limiting device on high speed machinery results from the ease with which dangerously high stresses can develop in case of governor failure. At ordinary steam turbine or dynamo speeds, the sound given off by the machine has a high pitch, and an increase of 100 or 200 r.p.m. does not attract the same notice from operators which would result at lower speeds. Moreover, an over-speed of 100 r.p.m. causes more and more increase in stress as the normal speed of the machinery in question becomes higher and higher.

Centrifugal force depends on the product of mass, radius, and the square of the angular velocity; and if we plot for various rotative speeds the centrifugal force tending to tear one pound of steel from the rim of a turbine disc 36 in. in diameter, we see in Fig. 2 that the force curve rises more and more rapidly as the shaft speed increases. With the governor out of service through a broken spring or pivot or through a stuck valve-stem, it is obvious that an underloaded turbine could easily develop stresses which would seriously diminish its factor of safety.

A simple problem will show this a little clearer.

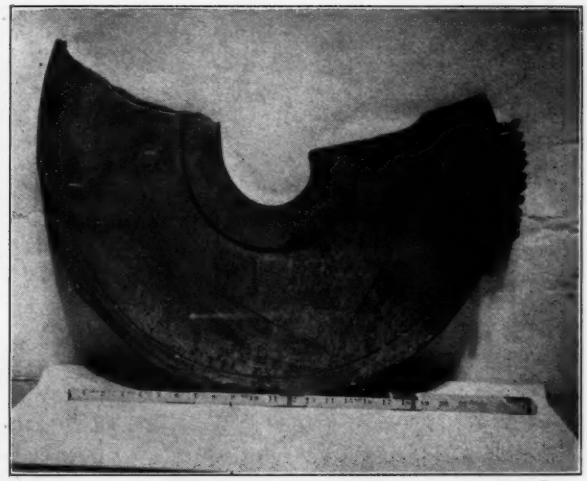


FIG. 1. WHAT CENTRIFUGAL FORCE CAN DO TO A TURBINE DISC

Suppose that at a certain normal speed the turbine disc is twice as strong as the stress it meets then. The stress from centrifugal force increases as the square of the r.p.m. so if we let the shaft speed increase to 1.41 times the normal amount (say from 1800 to 2538 r.p.m.) the force becomes doubled (or $1.41^2$), and the disc is about to rupture. If the over-speed stop operates at 10 per cent above the normal speed, the stresses from centrifugal force when the stop shuts the turbine down are of course $1.1^2$ or 1.21 times those at normal speed. It is not surprising that 15 per cent above normal speed is about the maximum limit used in setting over-speed stops.

Obviously, if such an automatic device is to protect, it must be kept in proper operating condition. A check on the behavior of the mechanism is readily made, and there seems no good reason why it should not be applied as a matter of routine, in much the same way as the boiler safety valve is checked. By pushing or pulling some accessible part of the governor mechanism, the turbine is easily speeded up while the operator keeps a wary eye on the tachometer (or perhaps on the voltmeter or frequency meter, in case the turbine drives a generator), releasing the governor if the stop does not operate properly. Why should not every turbine operator follow this practice as a matter of habit? It looks like remarkably cheap insurance.

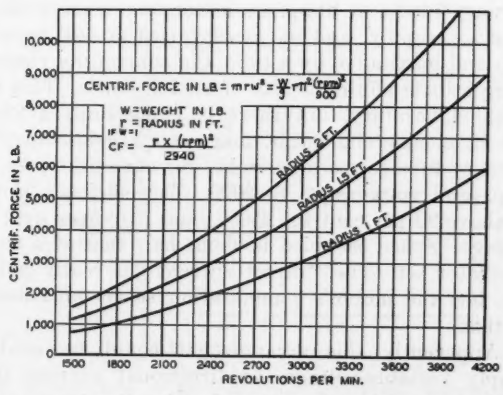
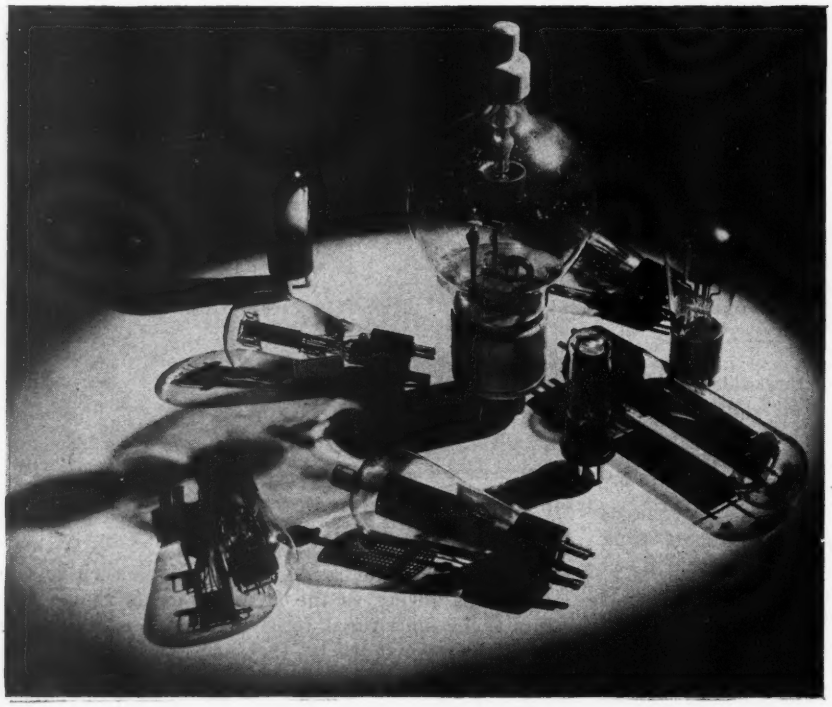



FIG. 2. THE FORCE EXERTED BY A ONE-POUND WEIGHT



# TUBES

Part Two

By

Hendley N. Blackman
Westinghouse Electric & Manufacturing Co.

**Further applications of tubes. Their use as converters of direct to alternating current and vice versa. Principles involved and basic theory underlying tube action. How the phase shift method of control works.**

IN THE PRECEDING article we indicated how tubes could be used as relays, as rectifiers, as lamps and as amplifiers. These applications though extremely useful are by no means the only ones. Tubes have many other uses some of which we will now consider.

As a rectifier we have seen that a tube is a conversion device capable of converting a. c. to d. c. The principle is reversible, however, and the same tube that converts a. c. to d. c. can be used to convert *d.c. to a.c. of any desired frequency.* The frequency is controlled and kept constant by the grid, which is excited by a properly tuned circuit. Since the grid requires only a fraction of a watt, this tuning is easy to do with very small condensers and reactors. The amount of alternating current power that can be obtained by this method at present is limited to about 15 amp. at 440 v. More can be obtained, however, if the demand develops.

## Variable Voltage D.C. from an A.C. Supply

Power Grid-Glow Tube (3 element hot cathode and mercury filled). A 10-hp. d.c. motor was recently driven from a.c. supply, and its speed varied at will between zero and maximum, by a tube, the controlling rheostat being a little affair the size of an ink-bottle. This was in the laboratory, but there is being built a 25-hp. 250 v., commercial outfit, and such a grid-controlled mercury tube seems practicable for currents up to 250 amp., and voltages up to 2000. The efficiency should be above 90 per cent for 250 v., and increases with the voltage. Space occupied is about half that of a motor generator set. The "direct current" is really pulsating, but the motor's commutation seems unconscious of this.

Apparently this arrangement could be used to supply variable-voltage, unidirectional current from an a.c. source for almost any purpose.

## How It Is Done

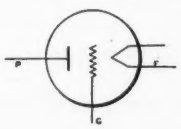
Tubes have the inherent ability to rectify alternating current, of course, and the mercury tube (especially suited for heavy currents such as this) is not so very different from the time-honored mercury rectifier, except that the anodes in its glass arms are enclosed by controlling grids. It is these grids which give the variable voltage feature. They can be set to chop off and use any fraction of the rectified wave,

**like this** **or this** **or this** **giving a**

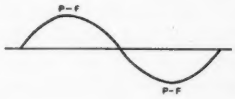
widely-varying effective voltage at the motor armature. The motor field is separately excited, from its own rectifier.

A little basic theory may not be out of place here, on the method of control, which is vital in the use of tubes for such purposes.

This is a Tube. The main power circuit, to be opened or closed, is connected between P and F. The "control circuit" is the voltage between G and F.



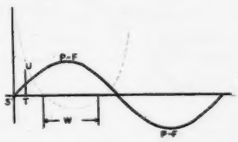

A sufficient "grid voltage" applied between G and F will cause the gap between P and F to break down and carry current until the plate voltage passes through zero, at the end of the half cycle. Viewing the tube as a relay, this "breakdown" constitutes the closure of the relay contacts.



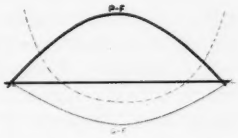

Here is the "plate voltage," the wave of A.C. power supply, connected between P and F.

# S May Solve Your Problem

The amount of "grid voltage" needed to cause the breakdown, or circuit closing action, between plate and filament depends on the instantaneous value of the plate voltage, and is shown by this curve.




At moment "S", when plate voltage is zero, no amount of grid voltage would cause "breakdown." As the plate volts increase, less and less grid voltage is needed to "touch it off." At moment "T", a grid voltage "U" will close the main (plate) circuit P-F: at W, the critical voltage needed is zero, and the plate circuit will close without any grid voltage at all.

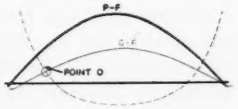


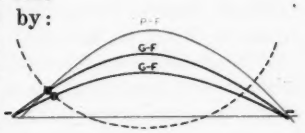

If you do not want this to occur, it can be prevented by applying a grid voltage of opposite polarity. For example, with the grid voltage shown on this curve, the tube never would "breakdown."

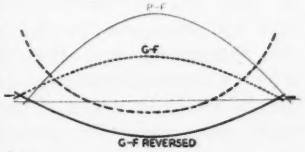
Tubes may be built with variously shaped "critical characteristics" such as A, B, and C. A will not break down at all unless the grid voltage helps it. The controlling "grid voltage" may be either d.c. or a.c.

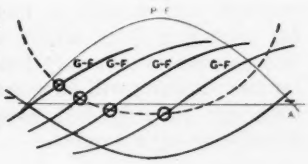
### There Are Three Ways to Control Tubes—

Here is a "grid voltage" wave in phase with the line (plate) voltage. The point "0" where it intersects the "critical characteristic" is the point of "breakdown," or closure of contacts; where the tube allows the main current to flow from plate to filament. Point "0" could be controlled by: making the *magnitude* of the grid voltage greater or less, which gives a small adjustment, or flopping the grid wave over (reversing its polarity) which will prevent the occurrence of "0" entirely—the tube will not "close its contacts" at all, or moving the grid wave sidewise (i.e. changing its phase relative to the main, or plate voltage). At A, the tube will never "breakdown" —it will not "close its contacts."




The last method of control appears of great commercial promise, and is analyzed below in greater detail for those engineers who wish to pursue the matter further.

FIG. 1. MERCURY GRID-GLOW TUBES FOR MOTOR CONTROL

### How the "Phase Shift Control" Works

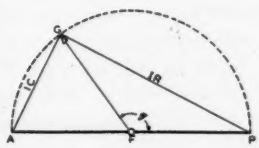
In Fig. 2 for example, is a typical circuit for half-wave output.

The main power circuit is from the center of the transformer (F), across the filament to the plate, through the load, to the end of the transformer winding (P).

The filament of the tube, of course is supplied from a source, not indicated but which may be either a battery, low voltage generator or a small step down transformer.

The control circuit (A-C-R-P) takes very little current. It consists of a fixed condenser (C) and variable high resistance (R) bridged across the power transformer winding (AP). The grid of the tube is connected between (C) and (R).

The vector diagram shows what happens when high resistance (R) is varied. The total voltage drop around the control circuit, is always made up of two voltage vectors at right angles to each other. (IC) is the voltage drop across the



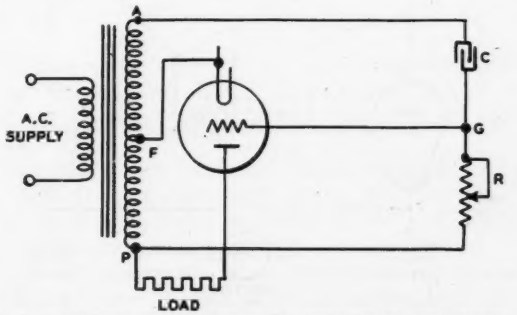




FIG. 2. VACUUM TUBE CIRCUIT SHOWING METHOD OF CONNECTING RESISTANCE AND CAPACITY

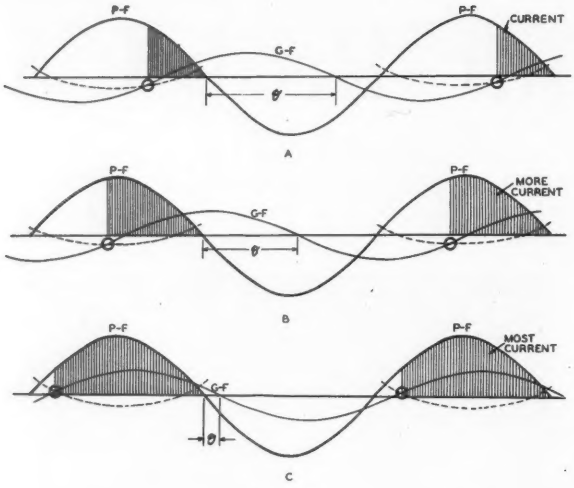



FIG. 3

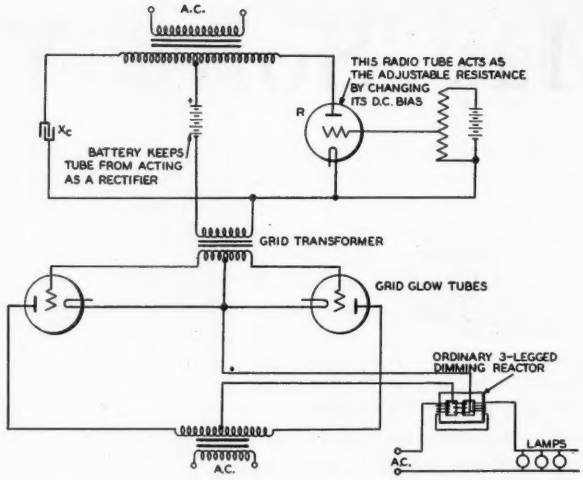



FIG. 5

fixed condenser; (IR) is that across the variable high resistance. A change of (R) changes the relative voltage drops across (C) and (R). Consequently, the vector (F-G), which is the grid voltage, traces a semicircle as sketched. Obviously, vector (F-G) fixes the phase angle (O) between the main power voltage (F-P) and the grid voltage (F-G).

As (R) is varied, the wave (G-F) (Fig. 3) is slid to the left as shown by these curves. As this grid voltage is advanced nearer and nearer in phase, breakdown occurs earlier and the slug of current gets larger, as shown. In "a" (G-F) has a large phase angle ($\theta$) with respect to (F-P). In "b" the angle ($\theta$) is less, and in "c" it is very small.

Having illustrated the principle of the phase shift method of control, we will now present several examples of control using this method. In Fig. 1 are shown two mercury grid-glow tubes for motor control. The circuit used in this set-up is shown below (Fig. 4). This single phase circuit uses two tubes to get full wave output. Mercury pool tubes of this sort are started by rocking them; once started, the two little horizontal electrodes ("keep alives") keep the tube filled with mercury vapor until the power circuit takes control.

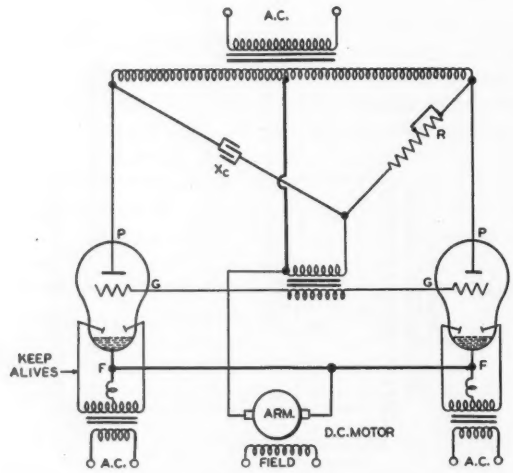



FIG. 4

Another application is shown in Fig. 5. Here, a grid controlled radio tube acts as the variable resistance to shift the grid voltage with respect to the plate voltage. Because the control grid handles no current (only potential) it makes "proportional dimming"—all groups of lamps keep the same relative intensity while being dimmed.

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JOINT ASTM-ASME Research Committee on Effect of Temperature on the Properties of Metals prepared last year tentative codes of recommended practice for the making of short-time high-temperature tensile tests, and long-time or creep tests. Adherence to the principles described in these codes bids fair to enable different laboratories to secure consistent and reliable results.

In order that such consistency may be demonstrated, and in order to aid laboratories in achieving consistency, there has been a demand for a standard material to use in cross-checking results from different laboratories. To meet this demand the Joint Committee is having prepared, through the courtesy of the Bethlehem Steel Corp., a supply of 0.40 per cent carbon open-hearth steel, specially made, selected, annealed and tested so that the supply is of an extreme degree of uniformity, and thus suitable for cross-checking or so-called calibration bar purposes.

The Joint Committee will supply this steel to those laboratories interested in finding out how well their short-time and creep tests agree with those from other laboratories. Such coöperating laboratories will agree to make the comparison creep tests at one temperature and load and for the length of time selected by the committee, and the short-time tests at a few selected temperatures, recording all the data required by the codes in order to show that at least the minimum precautions for accuracy required by the codes have been observed. Sufficient material for duplicate tests will be supplied if desired. The ASTM Headquarters can supply at nominal cost pads of forms for reporting data, which workers in this field will find convenient not only for this report, but for regular use. Results will be summarized and, when enough data are in, published, each laboratory being designated only by a symbol.

# *Procedure for* Check-up on Motors

**During Busy Days, the Tendency is to Pay too Little Attention to Electric Motors So, Slack Periods of Production Make Good Housekeeping Time**

**By Carl Heyel**

NO EQUIPMENT breaks down all at once. Motors are no exception and actual failure under operation should occur but rarely if proper inspection procedure is followed and tell-tale signs of approaching trouble heeded.

It will be well to draw up a list of the most essential motors in the plant, interruption to whose service would cause the most delay and inconvenience, and to look at them first. But this should have a logical follow-up program, going through the whole plant systematically, by departments and floors.

Some important data can be gathered by mere inspection, while others must be measured or calculated. The procedure may be summarized as follows:

DATA BY INSPECTION

1. Are surrounding conditions detrimental to the motor?
2. Do bearings need attention?
3. Is there sufficient oil; is it of good quality; and is it being taken properly by the bearings?
4. Are brushes in good condition?

MEASURED DATA

1. Take insulation "megger" readings.
2. Read terminal voltage under load.
3. Read line current.
4. Calculate power.
5. Is driven machine over or under-motored?

It is suggested that these separate points be checked on all motors. The tabulation in 8½ by 11-in. form, can easily be mimeographed and a permanent record kept, with space for control equipment, since it will be found convenient to examine that along with the motors.

Records kept in this way will give a bird's-eye-view of this portion of the plant equipment and will enable the engineer, by a few successive re-checks, to formulate a definite maintenance program: It will tell him whether certain departments abuse motors; whether certain machines are over or under-motored; and will go a long way in helping him establish definite oiling and cleaning schedules.

MOTOR CHECK SHEET

Motor No.....
Date .....
Dept. ..... Driven Machine .....
Location .....
Motor H.P.....Volts.....Amps.....
Type and Make.....
Surrounding Conditions .....
.....
Bearings .....
Oil .....
Brushes .....
.....
Megger Readings .....
.....
Full-Load Amps.....Full-Load Volts.....Power.....
Control .....
.....
Remarks .....
.....
.....
Re-check Dates .....

Environment is an important factor in motor selection and maintenance. If a motor is subjected to dripping water or other fluids, it will be advisable to protect it with a metal shield. If dusty conditions, corrosive fumes or explosive hazards exist, it may be advisable to substitute totally inclosed, or fan-cooled, inclosed motors for open types. The cost of such motors is about one-third or one-half greater than that of standard types but they usually pay for themselves in decreased maintenance and uninterrupted service.

Dust or flying material collecting on or in motors in such quantities as to interfere seriously with ventilation may cause dangerous temperatures; metallic dust may cause shorts and grounds; magnetic dust, by settling on the pole faces and effectively changing the air gaps, may make proper commutation impossible. Corrosive fumes and acids call for special coil impregnation.

## BEARINGS

Worn bearings are frequent causes of serious trouble and should be carefully guarded against. If bearing play is too great, the rotor of a motor will rub against the stator; frictional heat will quickly deteriorate insulation and cause grounds and short circuits.

To check for worn bearings, measure the air gap by means of standard thickness gages, sheaths of thin metal strips, of varying thickness, which can be inserted between the rotor and stator to determine the clearance. If such measurements, taken between the stator and upper portion of the rotor (with the motor, of course, stationary), and the stator and lower portion of the rotor show great difference, there is too much bearing play.

Smoking and a high-pitched, screeching sound indicate hot bearings, which may be caused by lack of oil, failure of oil rings to rotate with the shaft, or dirty or gritty oil.

Too much pulley tension, or misalinement of power transmission equipment, may cause the shaft to be pulled out of true. These points should be kept in mind when the bearings are examined.

In a well-maintained plant, all motors are checked for oil about once a week. Care should be taken that there is oil in the overflow. Rubbing the hand along

the inside surface of the end-bell will show whether oil is being squirted out in excessive amount which may be injurious to the stator windings. A defective oil thrower is probably the cause of such trouble, although there have been instances of poor design of fan-cooled motors, where so much suction was produced by the fan that the oil was actually drawn out of the bearing housing, instead of being thrown back into the oil well by the oil thrower.

Sticking oil rings will cause trouble. Foul and gummy oil is usually the cause, for it is difficult to keep ordinary motor bearings clean in dirty and gritty locations. If too heavy an oil is used on the bearings, oil rings will fail to function properly.

On commutator and slip-ring motors, the brushes should be checked for wear and contact. On slip-ring motors, the purpose of brushes is merely to establish good sliding contact; but on direct-current machines they perform the important function of commutation, hence should receive careful attention. Spring pressures should be equal on all brushes, so that each carries its share of the load.

Examination of the bottom of a brush will show, by the polish on that surface, whether all of the bottom area is really bearing on the commutator. If only part of the bottom surface of some brushes is actually in use, contact resistances will be unequal and proper commutation impossible to obtain.

Bad sparking is a danger signal pointing to probable brush trouble, unless the machine is operating under heavy overload. Dirt, brush disintegration due to long operation under heavy overload, improper brush angle and unequal spacing of the brushes around the commutator are common troubles which make themselves known by sparking. On the other hand, these factors may be absent and merely by shifting all brushes a bit sparkless commutation may be obtained.

Chattering and vibration will inevitably result if brushes are held in place by blocks placed over them to maintain proper spring tension, until they are worn down to the bottom of the holders. They should be renewed before chattering starts.

Motor leads should be disconnected and megohm readings taken between the leads and ground. This is important, because megohm readings enable anticipation of insulation failures, and permit preventive steps to be taken. Although no precise megohm standards can be set up, the following general rule may serve: If the meter shows a quarter of a million to a million megohms, the motor insulation is probably in excellent condition. If the value falls below a quarter of a million megohms, it will be well to watch the motor carefully. If the readings fall to around 50,000 or 100,000 megohms, it is a definite danger signal.

In the case of a direct-current machine, it will be well at this point to disconnect the armature from the field and give each a separate megohm test to locate the trouble. Around 50,000 megohms or less, the motor is in need of service shop attention, since at most plants no facilities are available for performing the work that this trouble calls for. The coils must be thoroughly cleaned with gasoline, which is forced in between the motor windings; the windings must then be thoroughly dried in a ventilated oven; finally, they must be impregnated with a good varnish or waterproof paint compound.

Voltage at the motor terminals at full load should be read. A voltage check at no load is no criterion, because, if the plant wiring is inadequate, the voltage may drop excessively when the motor draws full-load current; this fault would not show up in a no-load reading. Motors should be operated within the range of 90 to 100 per cent rated voltage. If the voltage is too low, the motor, in order to do the work required by the driven machine, will draw too heavy a current and will heat up; excessive heating will lead to insulation failure. If the voltage is too high, alternating-current motors will operate at decidedly poor power factor.

Ammeter readings should be taken with the motor driving its full load. They will eliminate the necessity of taking actual wattmeter readings, a less convenient procedure, because, from them the power input to the motor may be calculated. In the case of single-phase alternating-current, and of direct-current motors, the power in watts is the product of line volts and amperes. In the case of three-phase alternating-current motors, operating at approximately full load, the power input in watts is given by the following relation:

$$P = E \times I \times \sqrt{3}$$

where, E is line-to-line voltage; I is current in any phase.

This procedure is rather inaccurate, as it gives no consideration to the power factor of induction motors, which, at full load, is about 90 per cent. It will, however, give an approximation close enough to disclose whether or not a motor is suited to its load. If a motor seems greatly underloaded and an accurate determination is desired, wattmeter readings can be taken. Decreased efficiency and power-factor wastes result if a plant is largely over-motored.

It is quite possible that a motor survey, as here outlined, will dictate an appreciable shifting of motors to adapt them more nearly to the requirements of the driven machines.

When a motor check-up is undertaken, it will be logical to pay some atttention to starters and controllers. Contacts should be examined for excessive arcing. In the case of starters for wound-rotor motors, the resistors, which are usually cast-iron grids, should be examined to see whether any are fractured. Oil for immersed, auto-transformer starters used with squirrel-cage motors should be kept at the proper level. Holding coils should be inspected to guard against sticking.

As here outlined, this survey is not intended to include elaborate automatic control installations. Several points were kept in mind in arranging the check sheet, which is kept as simple as possible to avoid excessive "bookkeeping." Thus under such headings as Bearings, Oil, Brushes, no separate listing of individual items is given; it is left to the one making the inspection to jot down his recommendations in the space given. To keep the record from becoming too voluminous, a whole new form need not be made out for each re-check, since such items as Megger Readings, Full-Load Amps., Full-Load Volts will need checking less frequently than others. Date of the original survey should be marked in the upper right-hand corner. Re-check dates, when oil, bearings, brushes are looked at, can be jotted on the lowest line. Re-check dates should also be put in parentheses after the notations under the individual headings in the form. When later, a complete survey of the motor is made, a whole new form can be filled in to replace the old one in the files.

# The RELAXATION INVERTER

**Inverter is the name given to devices, particularly those using electronic tubes, for converting direct current into alternating current. Several types using more than one tube have been developed. The Relaxation inverter described here is such a device but one which makes use of only a single tube. While its output in its present form is limited to very small powers, it is quite possible that the principle employed may be extended to increase its output and consequently its application.**

FEW THINGS ARE more characteristic of this present age than the almost complete abolishment of the "it can't be done" attitude. Before the advent of world wide communication, of air transportation and synthetic chemistry, even those who were recognized and qualified to know most about certain subjects were often most emphatic in asserting that certain things could not be done. Today an entirely different attitude prevails; so many supposedly impossible things have been accomplished that few of us are willing to risk our reputations in claiming that anything is impossible.

In the electrical art this situation prevails to a high degree. Years ago certain things were regarded impossible in electrical engineering. Today largely because of the development of the thermionic tube and the application of the science of electronics, anything seems possible. One of the things which at one time was deemed impossible was the direct transformation of direct current from one voltage to a higher voltage using only static equipment. Today, on a small scale at least, this is an accomplished fact. Only slightly less impossible was the conversion of alternating into direct current with static equipment, yet today in nearly every radio receiver in the land are installed devices for doing this very thing.

This conversion of alternating into direct current, by the use of thermionic or electronic rectifiers, is quite generally understood. What is not so well known, however, is that by means of similar equipment direct current can be converted to alternating current of any desired frequency, and that by modifications of such arrangements direct current of one voltage may be transformed directly into direct current of a higher voltage. In view of what the electrical engineer of 20 or 25 yr. ago learned at school this last accomplishment is of unusual interest.

Devices used for converting direct current into alternating current are called inverters. Several types, all using gas or mercury vapor hot cathode electronic tubes have been developed during the past few years. In all instances these inverters employ two tubes. Recently a new type of inverter called the Relaxation inverter and using but a single tube has been developed. This development was described in an article by Herbert J. Reich of the University of Illinois in the December, 1933, issue of Electrical Engineering from which the material in this article was abstracted.

As described in Mr. Reich's article, the relaxation inverter is simple and reliable and gives unusually good wave form. A modification of this circuit using two tubes delivers double the output of a single tube and another arrangement provides a d.c. transformer

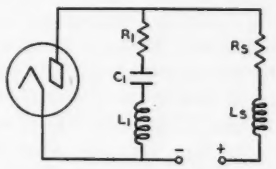



**Fig. 1. The Fundamental Relaxation Oscillator Circuit.**

by means of which it is possible to obtain voltages of from 300 to 500 v. from a 115 v. supply. These, of course, are small units with an output of only about 100 or 200 watts. A standard FG-67 thyratron tube is used.

To understand the operation of the relaxation inverter let us consider first the relaxation oscillator circuit shown in Fig. 1, using a simple two element gas filled rectifying tube. When direct current is first applied to the circuit the condenser $C_1$ charges at a rate and in a manner which is determined by the supply voltage and the circuit constants. No current flows through the tube until the voltage reaches the "firing" or breakdown voltage of the tube.

When the condenser voltage becomes equal to the firing voltage, the tube conducts, allowing the condenser to discharge through the tube which has negligible resistance when conducting. The current which is flowing into the condenser at the instant the tube breaks down transfers to the tube and subsequently varies in a manner which is determined by the supply circuit resistance and inductance $R_s$ and $L_s$. The total current through the tube, therefore, is the sum of the condenser discharge current and the current which flows from the d.c. supply through $L_s$ and $R_s$. The action of the inductance $L_1$ causes the condenser to continue to discharge to a negative voltage which, neglecting damping, equals the original positive voltage less the anode drop through the tube (about 10 to 15 v.). The condenser current then reverses and the net current through the tube becomes the difference between that coming from the d.c. supply and that from the condenser. If the inductance $L_1$ is small, the condenser current increases more rapidly than the supply current through $L_s$ and eventually becomes

equal to it. In this instant the anode current is zero, and the tube goes out. If on the other hand, $L_1$ is large and $L_s$ and $R_s$ small, the supply current may build up more rapidly than the condenser current, preventing extinction of the tube. By using a low value of $L_1$ the natural period of that branch of the circuit may be made so short that the condenser discharge and extinction of the tube take place in less than 0.001 sec. A small $L_1$ also results in a discharge current the amplitude of which may be 15 or 20 times the maximum supply current, so that the condenser

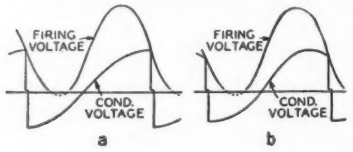



FIG. 2. CONTROL OF OSCILLATION BY MEANS OF COMBINED D.C. AND A.C. GRID VOLTAGES

current becomes equal to the supply current, and thus extinguishes the tube before the condenser voltages have decreased appreciably. Consequently, at the instant the tube is extinguished the condenser and d.c. supply voltages are additive and tend to increase the initial supply current. The condenser now recharges to a positive voltage and the cycle repeats. After the first cycle, because of the initial negative condenser charge and the initial supply current the condenser would charge to a voltage greater than twice the line voltage if the tube were prevented from firing.

In this way an alternating voltage is produced across the inductance $L_s$ and alternating current may be drawn from connections across its terminals, or from the secondary of a transformer in series with or replacing $L_s$.

With a system employing a two element tube such as described the power output is small due largely to the low firing voltage of the two element tube. There are other disadvantages which need not be considered here. In order to obtain substantial power output at commercial frequencies, it is necessary to raise the firing voltage of the mercury vapor tube. This in practice is most easily accomplished by means of a grid in the tube which is maintained at a constant negative potential. This, of course, is the ordinary grid controlled mercury arc rectifier. The use of a constant negative grid voltage to increase the firing voltages has two disadvantages. The first results from the small slope of the condenser voltage curve near the maximum. A slight variation of supply voltage, firing voltage, or load results in a large variation of frequency, or even in permanent extinction of the tube.

The second difficulty results from the fact that during the first cycle after the d.c. voltage is applied the maximum voltage to which the condenser can charge is lower than during succeeding cycles. If the firing voltage is high enough to allow full charging of the condenser after equilibrium is established then the tube will not fire at all. These difficulties may be prevented by applying, in addition to the d.c. grid voltage, an a.c. voltage field of desired frequency, the peak value of which is considerably in excess of that necessary to raise the firing voltage to a value equal to the maximum condenser voltage. The curve of firing voltage then intersects the curve of condenser voltage at a large angle, so that small variations of supply or control voltage or of load have little effect upon the value

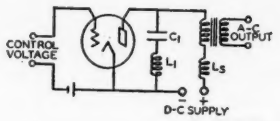



FIG. 3. SIMPLE GRID CONTROLLED RELAXATION INVERTER

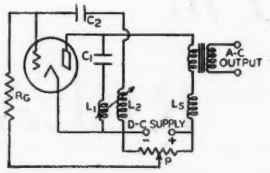



FIG. 4. SELF EXCITED RELAXATION INVERTER

of condenser voltage at which the tube fires. The frequency of oscillation is obviously the same as the control frequency. By proper adjustment of circuit constants and control voltages or fields the firing voltage may be made to equal the condenser voltage at the instant that the condenser is fully charged, as indicated in Fig. 2a. If the charging time of the condenser is less than the period of the control voltage, the firing voltage may become equal to the condenser voltage after the condenser is fully charged, as in Fig. 2b. The condenser will then start discharging back into the line before the tube fires, and the initial condenser current at the time of firing will be negative.

### Simplest Grid-Controlled Inverter

In Fig. 3 is shown the circuit of the simplest form of grid-controlled relaxation inverter. The necessary

FIG. 5. OSCILLOGRAM OF CONDENSER VOLTAGE, OUTPUT VOLTAGE AND SUPPLY CURRENT AT NORMAL LOAD



FIG. 6. OSCILLOGRAM OF CONDENSER VOLTAGE, OUTPUT VOLTAGE AND SUPPLY CURRENT UNDER LIGHT LOAD

grid excitation may be supplied by any type of oscillator, by a standard a.c. supply, or may be fed back from the output through a suitable phase shifting circuit. An air core reactor of about 1.3-mh. inductance made up of No. 10 wire wound in optimum inductance shape has been found to give most satisfactory results for $L_1$. A capacity of from 10 to 40 mf. is used for $C_1$, the exact size being somewhat dependent upon tube, frequency, and load. By using a small capacity, and hence a natural frequency which is high compared to the excitation frequency, several condenser oscillations may be made to occur for each cycle of the output. This is ordinarily not desirable since it results in very poor wave form of output voltage. The inductance $L_1$ is necessary under heavy load, due to the reduction of transformer inductance, and is frequently desirable at light loads in improving wave form, as will be explained later. The tube of the type known as FG-67 thyratron gives excellent results in this circuit.

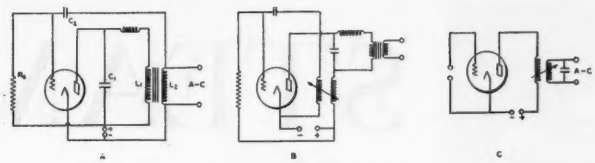


FIG. 7. OTHER TYPES OF RELAXATION INVERTER CIRCUITS

A self-excited circuit which gives excellent results is shown in Fig. 3. $L_2$ is an air-core inductance having a comparatively large number of turns, which is coupled to $L_1$. The discharge of $C_1$ through $L_1$ induces in $L_2$ a high voltage which causes a momentary flow of current through the tube by way of the grid and thus charges the condenser $C_2$. At the end of the discharge of $C_1$ the tube has ceased to conduct and, because of the rectifying action of the grid, the negative charge on the grid and condenser cannot leak off through the tube. Consequently the grid has a high negative potential which prevents the tube from firing until the charge on the condenser has leaked off through the high resistance $R_g$. The frequency depends upon the circuit constants and may be readily adjusted by varying the coupling between $L_1$, and $L_2$, the value of $R_g$ or the setting of the potentiometer P. Making the slider of the potentiometer more positive increases the rate of change of grid voltage at the instant of firing and therefore improves the constancy of frequency. Hence the potentiometer may be omitted and $R_g$ connected directly to positive side of the line. Equally good results are obtained by coupling $L_2$ to $L_s$. By a proper combination of the two methods of grid coupling the frequency may be made practically independent of load variation. $L_2$ also may be replaced by the secondary of the output transformer. It is not necessary to make use of the rectifying property of the grid, since the rectification may be accomplished by means of an auxiliary rectifier or an auxiliary anode in the tube. In this manner it is possible, in fact, to employ an external grid tube in the inverter.

In this way then direct current is converted into alternating current, the frequency of which may be determined by correctly proportioning the resistances, conductances and capacities of the circuit. As shown by the oscillogram in Fig. 5 the wave shape ($V_o$) of the output voltage when supplying current at normal load is remarkably good. The loading of this inverter affects the output wave shape to a considerable extent as is shown by the oscillogram in Fig. 5. This is due largely to the characteristics of the output transformer. For this reason it is best so far as wave form is concerned to design the transformer so that its inductance under load is small and to provide the necessary supply circuit inductance by means of the series reactor $L_s$.

## Modifications

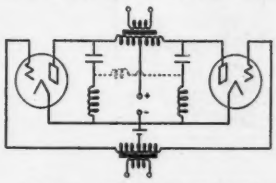
In the foregoing, the relaxation inverter has been described in its fundamental form. It can, however, be modified in various ways as shown by Fig. 7. In the circuit shown at A the inductance $L_1$ is necessary under heavy load and may be used at light loads to include wave form. To prevent the reduction of grid control voltage with increase of load it is sometimes better to derive this voltage from a separate coil coupled to $L_1$ instead of from the transformer secondary. In this type of circuit the condenser charge is sudden through the tube and discharges slowly through the transformer and $L_1$.

Another modifications is shown in Fig. 7B. Another type of circuit which under proper conditions will oscillate in a stable manner is shown in Fig. 7C. A theoretical analysis (considering circuit resistance) readily shows that when voltage is first applied to the circuit the current in the primary coupled circuit is a damped oscillation superimposed upon an exponentially increasing current. With small damping and close coupling the direction of the current may actually reverse, causing the tube to go out. The coupling would have to exceed 70 per cent with zero damping and because of circuit resistance the power delivered to the load must be considerably higher than any practical circuit. The coupled inductances may be the primary and secondary of a power transformer, the power being drawn from either primary or secondary. Any method of grid excitation is applicable.

A two tube circuit which has the advantage of double output is shown in Fig. 8. It is impractical to make this circuit self-exciting by the method employed in the single tube circuit of Fig. 4, so it is made self-exciting by using the output voltage to excite the grids. The wave form obtained with this circuit is less satisfactory than that obtained with single tube circuit.

Finally we come to another useful modification of the relaxation inverter which makes possible the direct transformation of direct current from low to high voltage. Several forms of circuits are available, the one shown in Fig. 9 being typical. The condenser $C_3$ is charged from $C_1$, through the rectifier tube to a voltage which approximates the peak voltage of $C_1$. It may be readily shown that when the ratio of inductance to resistance in the supply branch of the circuit is high, the peak voltage of $C_1$ may be many times the d.c. supply voltage. No difficulty is experienced in obtaining from 80 to 100 ma. at 300 to 500 v. from a 115 v. source with a tube of the type FG-67 thyratron.

Thus, the seemingly impossible problem of transforming direct current has been accomplished, on a small scale to be sure but in accordance with sound



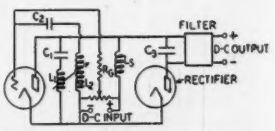
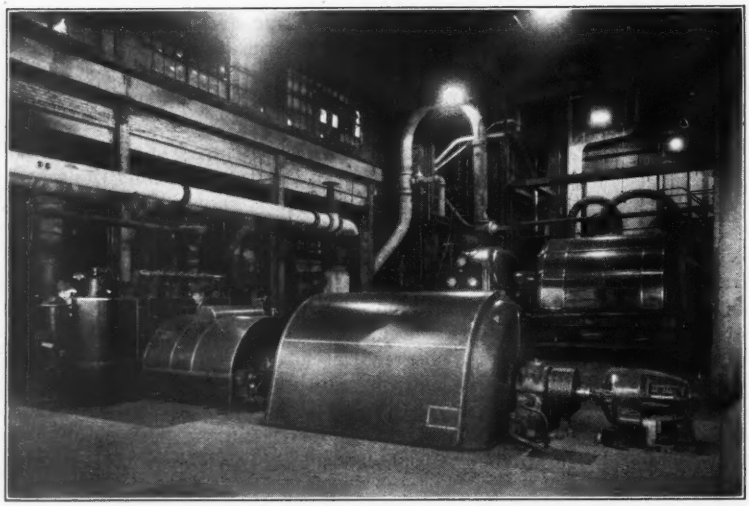



FIG. 8. TWO TUBE RELAXATION INVERTER CIRCUIT
FIG. 9. "D.C. TRANSFORMER" CIRCUIT

principles which undoubtedly permit of further development. As pointed out in the conclusion of Mr. Reich's article the relaxation is simple, reliable and provides a wave form that is good. At present its voltage regulation is poor, but in some applications such as neon sign work this is desirable. We present the article here not so much with the idea of describing a fully developed device but rather to stimulate thought both as to its further development and to its application.



# STEAM

**Goodyear Tire & Rubber Co. Install 300,000 Lb. Per Hr., 800 Lb. Boiler and 7500-kw. Non-Condensing Extraction Turbine at Akron, O., Factory. By Harry A. Davis, Manager, Steam Engineering Division**

AS THE AKRON FACTORY of the Goodyear Tire & Rubber Co. is the largest rubber factory in the world, with requirements for process steam and electric power proportionately large, the management in 1933 requested a study to determine what benefits could be derived from a high pressure boiler and turbo-alternator installation.

After carefully considering records of steam requirements, a plan was formulated whereby several of the boilers in the old plant would remain available for emergency service and the remainder of steam requirements would be supplied from a new boiler unit. After investigating 550, 650, 750 and 1200 lb. pressures, it was decided that an 800 lb. pressure, 750 deg. F. total temperature plant was the most attractive proposition for our conditions.

Space available for the new plant was limited to the existing plant so four of the old boilers were removed and the roof of the building raised to enable the installation of a new boiler. The existing coal and ash handling equipment was adapted to the new unit and a new turbo-alternator installed in space already available in the turbine room. The curtain wall between the boiler and turbine rooms was removed as shown by the photograph in the headpiece so that the operator has a clear view of all equipment under his control. The unit operates to a large extent automatically, with a minimum of manual control and under normal conditions the unit will be fully automatic.

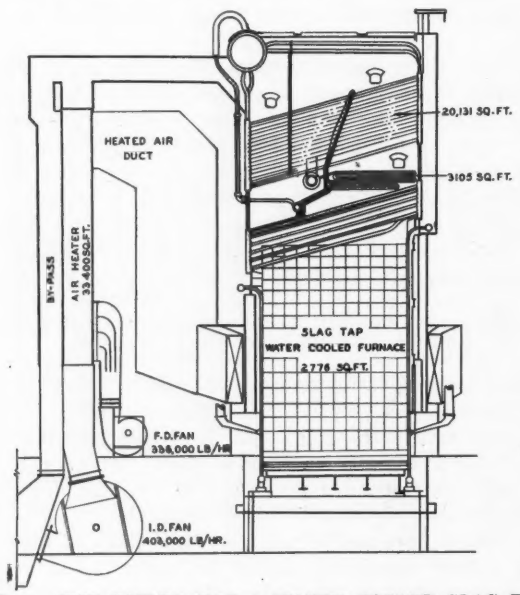



FIG. 1. THE BOILER HAS A WATER COOLED SLAG TAP BOTTOM

### New Construction vs. Reconstruction

Advantages of this plan were: deferment of part of the investment for the ultimate plant; abandonment of the old plant when necessary; ease with which future growth of steam requirements could be taken care of by replacing the older units with new equipment. The reconstructed plant has the disadvantage of poorer efficiency as compared with an entirely new installation due to the loss resulting from lower stage efficiencies in the low pressure turbines; poorer efficiencies of the generators; increased mechanical losses and loss due to pressure drop in the high pressure turbine header.

On the other hand the reconstructed plant possesses several distinct advantages: the initial investment is low; the capacity of the system is increased by the output of the new high pressure unit; the old prime movers which because of their high fuel consumption would otherwise be obsolete are maintained in regular service; the flexibility of operation is greater as the reconstructed plant allows individual operation of the present low pressure turbines during inspection or repairs to the high pressure unit, and, as the low pressure boilers are maintained for standby service, such operation is also possible in case of trouble with the high pressure boiler.

At that time steam was delivered from the boiler room at 200 lb. ga., 530 deg. F., directly to a steam header supplying all generating equipment in the present power house, and through a reducing valve, process steam to the factory at 100 lb. ga. for heating and various process curing. In analyzing the previous records for a period of five years, it was found that approximately 50 per cent of the steam generated went to

# M and POWER for the World's Largest Rubber Factory

process and 50 per cent was used in generating various power requirements.

In analyzing process steam requirements separately it was found during a period of a year the process steam load fluctuated from 150,000 lb. per hr. minimum to 285,000 lb. per hr. maximum. As the process steam demands were practically constant it was desirable to make this new installation a base load unit, operating 100 per cent of the time with a 100 per cent load factor. With a minimum of 150,000 lb. of process steam per hr., it was necessary to install a non-condensing extraction type turbine generator.

### Boiler Unit

In selecting the steam generating equipment the boiler, furnace, superheater, air preheater and pulverized coal burners were considered as a unit, each component part being proportioned to give a well-balanced economically efficient installation.

The boiler is a Babcock & Wilcox horizontal, cross drum, sectional type, with a capacity of 300,000 lb. of steam per hr. and designed for 800 lb. working pressure, or 745 lb. and 740 deg. F. total temperature at the superheater outlet. The effective heating surface of 20,131 sq. ft. is made up of 33 tube sections, 22 tubes high and 24 ft. long. The drum is 54 in. diameter by 32 ft. 11/16 in. in length. The interdeck super-heater has a heating surface of 3105 sq. ft., and the tubular air heater has an effective heating surface of 33,400 sq. ft. The air heater is so designed that in case of induced fan failure the heater will be by-passed automatically and operated on natural draft up to 50 per cent of the maximum rating.

Bailey stud construction will be used on all four walls from a height approximately 1 ft. to 13 ft. above the floor and Bailey smooth bare metal blocks will be used in all four walls above the studded portions. Presenting a continuous heating surface to the fire the total area of the water cooled furnace and floor is 2776 sq. ft., and at maximum load the heat liberation will be 32,700 B.t.u. per hr. per cu. ft. of furnace volume. The slag and ash resulting from combustion are kept in a molten state in the furnace bottom and drawn off at suitable intervals into a specially designed sluice.

The boiler is equipped with four Babcock & Wilcox pulverized coal cross tube type burners, two of which are placed on each side of the boiler. Each two burners are fed by a Babcock & Wilcox Type B, size 226, pulverizer with a capacity of 22,500 lb. per hr., at a fineness of 80 per cent through 200 mesh.

Coal is dumped from hopper-bottom cars into a track hopper. The coal from the track hopper is fed through a crusher and is conveyed by an apron feeder of the pan type into a pivoted bucket conveyor, which runs the entire length of the boiler room bunker and is equipped with an automatic tripper for distributing raw coal to the bunkers. The ash is removed by the same conveyor and is deposited into an ash bin directly over the railroad track for disposal in railroad cars. As arranged at present the coal-handling equipment has a capacity of 100 t. per hr.

The fan system, consisting of one induced draft fan and two forced draft fans, was designed to handle

FIG. 2. BOILER AND COMBUSTION CONTROL PANEL LOCATED SO THAT THE OPERATOR CAN OVERLOOK BOTH THE BOILER AND TURBINE ROOMS

the air and gases when the boiler is operating at its maximum rating of 300,000 lb. of steam per hr. The induced draft fan is designed for maximum delivery of 403,000 lb. per hr. of gas, at 467 deg. F. against a negative static pressure of 10.24 in. of water. The forced draft fans are designed for maximum delivery of 336,000 lb. per hr. of air at 80 deg. F. against a static pressure of 7.51 in. of water. The 600 hp. induced draft motor and both 125 hp. forced draft motors are 50 per cent speed controlled Allis Chalmers slip ring splash proof type with enclosed collector rings.

A Cochrane hot process water softening system was installed complete with deaerating heater, and the Hall system of phosphate feeding. At present approximately 50 to 60 per cent of the makeup water is condensate returns from the factory and is slightly contaminated. This supply is collected into a large surge tank and pumped directly to the water softener. The condensate from the present turbines will be piped direct to the deaerating heater. The balance of the makeup supply is taken from the city water main. The steam for heating the feedwater is taken from the exhaust system which collects the flash steam from the continuous blow down system and the exhaust from all steam driven auxiliaries.

The deaerating heater is designed with a storage capacity of 7500 gal. from which boiler feed suctions are supplied. There are two boiler feed pumps, each with more than sufficient capacity to supply the new boiler. Both operate at 3550 r.p.m. This high speed reduces the size and cost of the units and makes them well adapted to direct drive by either motor or turbine. The pump ordinarily used is driven by a squirrel cage motor and the reserve pump by a turbine which exhausts into the exhaust system for heating feedwater. The control on the motor-driven pump is so designed that in case of any electrical disturbance the steam driven unit will automatically pick up the load. The piping presents no special features, other than allowing the boiler to be fed at either end of the drum, at one end through an automatic regulator preceded by a differential pressure valve to regulate the pressure across the regulator, at the other end through an entirely independent line by a manually operated valve.

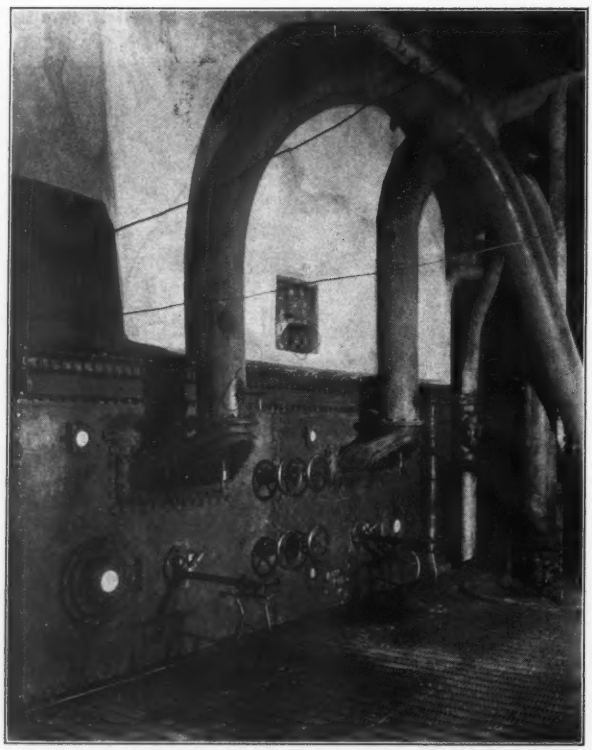


FIG. 3. FOUR BURNERS, TWO ON EACH SIDE OF THE BOILER, ARE USED

### Piping System

All high pressure steam piping and feedwater lines are of seamless drawn steel tubing and all high pressure steam joints 6 in. and above are the Sargol Type, except those connecting immediately to the boiler, superheaters and turbine. These particular joints, as well as all steam joints between 6 and 1½ in. are small tongue and groove. Steam joints below 1½ in. are large male and female. Only lap flanges are used. All tongue and groove or male and female facings being made in the lap of the pipe. All joints in the boiler feed lines are small tongue and groove. Copper gaskets are used in the tongue and groove and male and female connections.

There will be one Republic boiler control master sender, which due to its small size can be mounted on the rear of the instrument panel. This master is connected to the steam header pressure and will build up a varying air pressure dependent on the steam pressure. This variable pressure which has a minimum value of 10 and a maximum value of 50 lb. is the master impulse which controls the fuel and air supply and the furnace draft. Each change in uptake draft produced by a change in load tends to alter the draft in the combustion chamber. In response to such changes a combustion controller acting as a furnace draft regulator, will control the speed of the forced draft fan and the position of the damper between the fan and the burner.

### Turbine Room

In order properly to proportion fuel and air with the system of combustion control, actual tests on the boiler in question are used to determine the proper adjustment. For each boiler load the master will generate a definite loading impulse which is balanced by the draft at the boiler outlet. For each draft at the outlet tests are made to determine the proper speed of the feeder to introduce the amount of coal required to give the desired fuel-air ratio.

The turbo-generator is a General Electric non-condensing extraction type, with direct connected exciter, and rated at 7500 kw. at 0.75 p.f., 3600 r.p.m., when supplied with steam at 725 lb. ga., 725 deg. F. The turbine is arranged for single extraction of steam at 200 lb. ga. When no steam is being extracted the turbine operates as a straight non-condensing unit, all steam passing to the exhaust at 100 lb. ga. for factory process uses.

No elaborate changes were necessary in the electrical distribution system and by utilizing available space on the present switchboard and with the addition of one 3000 amp. oil circuit breaker, it was possible to connect directly into the present bus system.

# THERMAL INSULATION *with* Aluminum Foil

**By Taking Advantage of the High Heat Reflecting Quality of Bright Surfaces and the Low Conductivity of Air an Excellent Insulation Is Made with Aluminum Foil. By J. F. O. Stratton***

THERMAL INSULATION is becoming more important, especially in those industries such as paper, where not only the conservation of heat and the maintenance of predetermined temperatures are important, but where insulating materials are subjected to unusual conditions, contributing to deterioration. The use of aluminum foil is a complete departure from the physical characteristics of all other insulating materials. Aluminum is an extremely efficient conductor of heat, especially in the wrought sheet form, having a conductivity of 1430 B.t.u. per in. thickness per deg. F. difference per sq. ft. per hr. This is diametrically opposed to a great many other insulating materials, which have the characteristic of low density, and indicate their efficiency as insulation, almost directly parallel with their specific weight and density.

Efficient insulation is obtained with aluminum foil, not only by high reflectivity of its surfaces, but also by the additional insulating effect obtained in the air spaces between the various layers. Thus by laying three layers of aluminum foil in a one inch space, having two 3/8 in. air spaces, between the layers, and two 1/8 in. air spaces between the hot surface and the cover of the insulation, an insulating efficiency of a high order has been obtained.

Aluminum foil insulation is the ultimate development of the application of a theory propounded as far back as 1850, at which time, Peclet, a European scientist, recognized the principle which accomplishes thermal insulation by the reflection of radiant heat from a bright surface. He found, however, due to the thickness of the bright metal employed by him as well as the rapid corrosive or oxidizing character of the metal, that the reflective surface plate absorbed considerable heat, necessitating continual repolishing to obtain maximum efficiency.

Several years ago, Ernst Schmidt, studied the results obtained by Peclet, and carried on from that point in this development, employing aluminum, a more recently developed product, having the characteristics of permanent brilliancy. Furthermore, Dr. Schmidt employed foil as thin as 0.0003 in., which, due to its extremely low metal volume, would retain little heat as compared with a thicker plate employed by Peclet.

Dr. Schmidt and Dr. Dykerhoff of Germany, collaborated in the development of aluminum foil insulation, and obtained patents on the employment of an insulating structure comprising a casing with a plurality of layers of gas or air, these layers of gas being separated by very thin readily flexible sheets, of bright metal.

*Engineer, Ross Industries Corp., New York, N. Y. From a paper presented before the T.A.P.P.I.

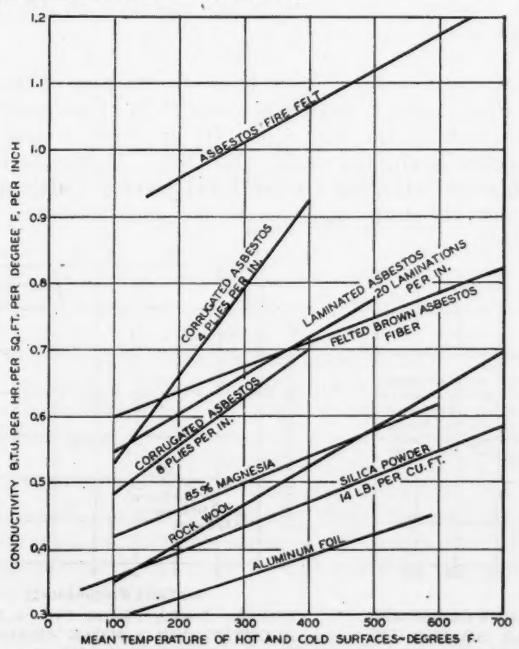

CONDUCTIVITY B.T.U. PER HR. PER SQ. FT. PER DEGREE F. PER INCH
MEAN TEMPERATURE OF HOT AND COLD SURFACES-DEGREES F.
ASBESTOS FIRE FELT
CORRUGATED ASBESTOS 4 PLIES PER IN.
LAMINATED ASBESTOS 20 LAMINATIONS PER IN.
FELTED BROWN ASBESTOS FIBER
CORRUGATED ASBESTOS 8 PLIES PER IN.
85% MAGNESIA
SILICA POWDER 14 LB. PER CU. FT.
ROCK WOOL
ALUMINUM FOIL

FIG. 1. CONDUCTIVITY OF VARIOUS HEAT INSULATING MATERIALS

## Method of Application

To accomplish the spacing of the foil, two methods are possible; first, to stretch the thin sheets in a frame to separate the layers of air, second, to crumple the sheet, by means of which the foil is kept apart, due to the fact that the crumpled surface presents a very minute contact area and obtains the desired spacing, definitely separating the layers of air between the foil. The crumpling method is for all practical purposes equally as efficient as stretching the foil in frames. By spacing the foil, through crumbling, an extremely light thermal structure is developed, having a weight of 3 oz. per cu. ft., or 1/4 oz. per board ft.

Numerous tests place the coefficient of conductivity of aluminum foil insulation at 0.28 B.t.u. per sq. ft. per hr. per in. thickness per deg. F. temperature difference at 100 deg. F. M. T. D. This is based on the application of three crumbled layers of foil, per inch thickness. Aluminum foil insulation is normally covered with a sheet metal jacket or housing. This jacket is supported on point contact spacers.

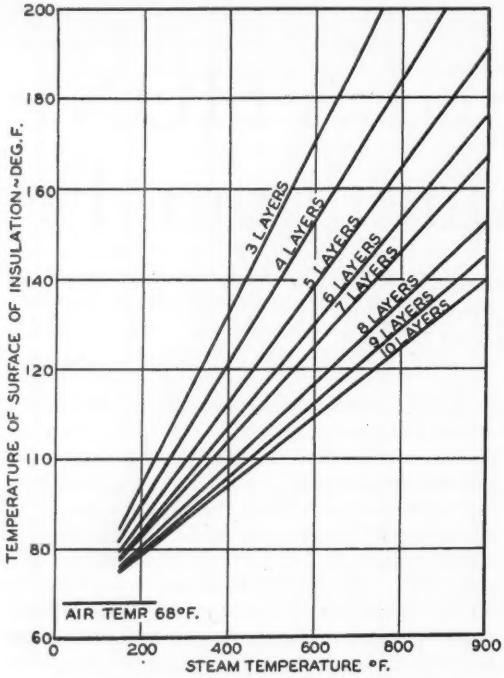



FIG. 2. SURFACE TEMPERATURES OF ALUMINUM FOIL INSULATION ON STEAM PIPES

The relationship between conductance and width of single aluminum foil-air cell insulations at mean temperatures of 100 and 150 deg. F. is shown in Fig. 3 plotted from test data. In drawing smooth curves through the points, a minimum conductance is indicated as occurring for air spaces about 0.63 in. The derived series of curves, Fig. 4, was plotted for 2 in. of insulation, using the curves of Fig. 3, for the condition where the cold face of the insulation is at 40 deg. F. For example, the conductance of a single air space ½ in. in width at 100 deg. F. may be taken from the curve in Fig. 3. The conductance of four air spaces (2 in. in total thickness) will be one-fourth the conductance of a single air cell. As the number of air spaces in 2 in. of insulation is increased from four to eight, a decrease in conductance is noted. The difference between the conductance of the insulation containing seven air spaces and the one containing eight air spaces is small; the one extra foil adds to the insulation value by decreasing slightly the small fraction of heat transmission by radiation.

Optimum spacing for the air cells with a given number of aluminum foils would be about 0.6 in., as is shown in Fig. 3. Where maximum insulation must be obtained in any given space, however, the minimum conductance is obtained by using more foils with closer spacing. Figure 5, which is from the data of Fig. 4, shows the relationship between the conductance, at a mean temperature of 60 deg. F., of 2 in. of aluminum foil-air cell insulation and the width of individual air cells. The insulation containing eight air cells per 2 in. gave the lowest value in this series of measurements. If the conductance of 2 in. of insulation containing ten air spaces is calculated, it will be found to have approximately the same value as the one containing eight air cells.

This insulation will not disintegrate, rot, warp, or settle. Vibration tests have been made of the crumbled form of aluminum foil insulation, one of which was on a vibrating apparatus at 4000 vibrations per hour for 50 consecutive hours, the structure and layers were unaltered at the end of that period. It being non-hygroscopic, vegetable and bacterial growth cannot form within. Spaces insulated with foil may be filled with water to actual overflow. As soon as the water is drained off the efficiency of insulation is not impaired.

The insulating efficiency of aluminum foil under normal conditions is established; and while the coefficient of conductivity is important, as an indication of heat loss, the surface temperature on the outside of the insulation casing is an immediate indicator of heat conservation when compared with the known inside temperature of the insulated chamber or pipe. Figure 2 shows the surface temperatures obtained with various thicknesses or layers of foil in crumpled form, with atmosphere 68 deg. F. These are subject to 10 deg. F. variation.

As previously stated, aluminum foil is applied normally, three layers per inch thickness of insulation. Little change in efficiency is obtained with other spacing, however, and three layers installed in 1¼ in. space would give approximately the same result.

The weight of foil insulation including its outer sheet metal jacket is very low. In the case of insulated pipe lines, it usually is about 10 to 15 per cent of the weight of the bare pipe. Its insulation weight is therefore negligibly small. (Ed. Note: Aluminum foil insulation, including a sheet metal cover is understood to cost about the same as 85 per cent magnesia installed.)

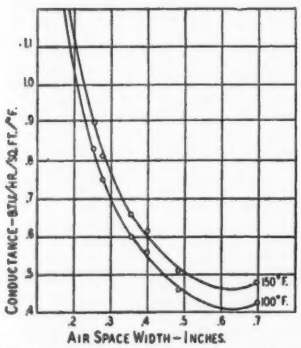



FIG. 3. WITH A SINGLE FOIL AN AIR SPACE OF ABOUT 0.63 IN. GIVES LOWEST CONDUCTANCE

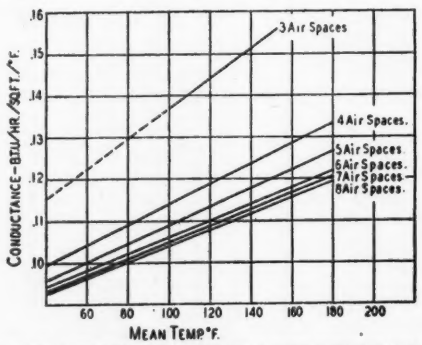



FIG. 4. CONDUCTANCE VALUES DECREASE AS THE NUMBER OF AIR SPACES INCREASE. ABOVE 8 THE DECREASE IS SMALL

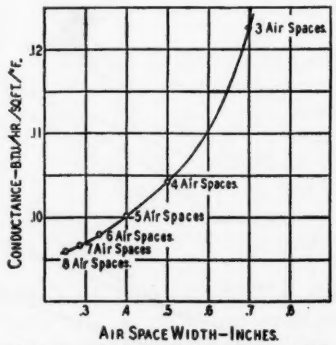



FIG. 5. DATA FROM FIG. 4 REPLOTTED FOR A MEAN TEMPERATURE OF 60 DEG. F.

# Development *of the* HUMPHREY PUMP in America

**Substitution of Water for Conventional Gas Engine Piston Forms Displacement Pump of High Efficiency**

By F. Du P. Thomson*

EXTENSION in the distribution of low cost natural gas and propane has opened up a wide field for the adoption of the Humphrey pump, not only for the supply of water for municipalities and industrial plants, but for the production of peak-load electric power in connection with pumped-storage projects. At the present time there are three installations of Humphrey pumps in condition to operate. The largest of these, that at Chingford, near London, was put in commission in March, 1913, for the Metropolitan Water Board and consists of five pumps having a combined capacity of 250 m.g.d. against a head of 30 ft. The official acceptance tests gave a consumption of anthracite coal per actual water horsepower-hour ranging between 0.80 and 0.95 lb.

Successful operation of the Chingford Station led the Irrigation and Drainage Commission of South Australia to install two pumps, each with a capacity of delivering 28,000 g.p.m. against a head of 27.5 ft., at Cobdogla on the River Murray. Since May, 1930, this station has been in regular and satisfactory operation. Tests indicate a fuel consumption of 4.15 lb. of air-dried Mallee wood per water horsepower-hour. Both of these stations are equipped with pumps of the four-cycle type originally developed by Mr. Humphrey.

After considerable development work by a licensee of the American owners of the Humphrey patents, the Sun Shipbuilding & Dry Dock Co. of Chester, Pa., installed at its yard a 36-in. pump of the two-cycle Steckle-Humphrey type. This pump has been operated at heads ranging from 20 to 120 ft. with perfect success. For 2 yr. after its completion it was kept in operation for 7 hr. daily as an endurance test, and for two weeks during that period it supplied all the water for the shipyard, approximately 2000 g.p.m. at a head of 120 ft. in regular 24-hr. service. Since this period the station has only been operated when there was occasion to make a demonstration. No changes have been made to any parts of the pump since its installation.

In this type of pump the conventional engine piston is replaced by a column of water as shown by the six stages of operation in Fig. 1. The complete pump is shown only for the sixth stage. Water is pumped from the pool S into the pressure main L, entering the pump through the valves I at the period in each cycle when the interior pressure at the gas end is down to atmospheric, and discharging through the valves O into the air chamber C. Discharge is the result of the momentum of the long column of water M, acquired from the expansion of the burning charge of gas at the top of the gas end.

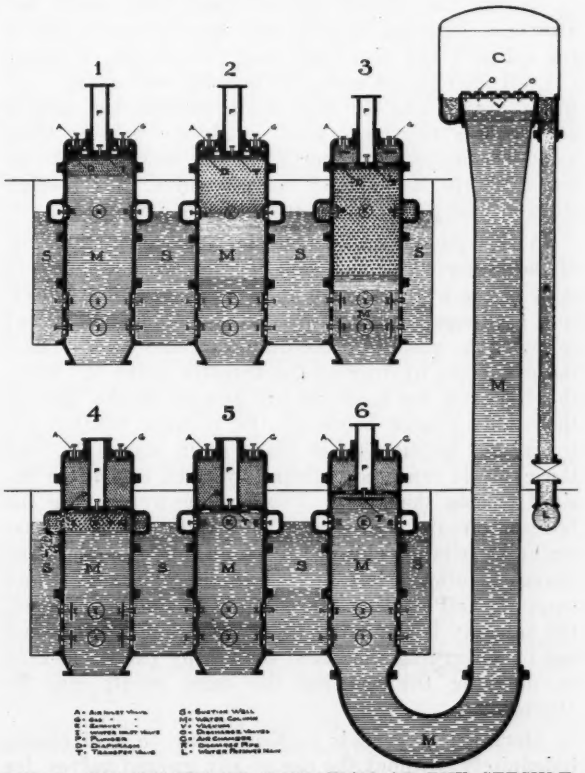



FIG. 1. SIX STAGES OF OPERATION OF THE STECKLE-HUMPHREY PUMP

*Elkton, Md., Consulting Engineer, Sun Shipbuilding & Dry Dock Co., American licensees for the Steckle Humphrey two-cycle pump. From a paper presented before the A.S.M.E.

The action of the gas end depends principally on the action of the light diaphram piston D, to which is attached the hollow displacement plunger P. The diaphram D serves principally as a separator between the incoming charge above it and the burned gas below it, and hence has no packing rings and fits in the cylinder with an easy working clearance. The weight of the diaphram and plunger, when allowed to descend into the cylinder, serves to draw in the charge of gas and air as will now be explained by reference to the diagrammatic arrangement Fig. 1.

In stage (1), everything is stationary, a compressed explosive mixture is between the water surface and the head of the cylinder, the head being covered by the diaphram D, which is held up by interior pressure effective over the area of the plunger P. All the valves are held closed by interior pressure, those valves being the gas and air admission valves G and A, exhaust valves E, and the water inlet valves I. All the valves have closing springs except the exhaust valves which have light opening springs. At this instant, with all valves closed, ignition takes place, by means of high-frequency spark plugs, and the charge is fired and expands out to the volume indicated in stage (3), reaching atmospheric pressure at about that volume.

An intermediate stage of expansion, corresponding to the original un-compressed volume of the charge is shown in stage (2). Here, atmospheric pressure being reached, the exhaust valves are opened by their light springs, the diaphram is no longer held up by interior pressure and descends to the level of the exhaust valves, pushing out the exhaust gases below it and drawing in a new charge above it through the gas and air valves G and A.

During the descent of the diaphragm, water has also been entering through the inlet valves I, filling the cylinder and also displacing burned gas. In stage (4), all the exhaust gases are out, the new charge and water are in and the long main column, the motion of which is relatively slow, is about ready to start back to compress the charge. Water now starts to go out through the exhaust valves, which thus become clogged and gently close and compression begins.

A few pounds of compression, acting on the area of the plunger P is sufficient to raise the diaphram M clear of the water surface and further rise of compression produces a lifting force on the plunger sufficient to make the gas above the diaphram find its way past the diaphram by way of the transfer valve T. When the diaphram has made its full upward stroke, leaving the whole charge below it, the plunger touches the timer and ignition takes place as in stage (1), and the cycle is repeated indefinitely until it may be desired to stop the pump. This is done by opening the ignition circuit. This leaves everything ready to start again by simply closing a switch for a compressed charge is always left unfired in the cylinder. Since stopping and starting the pump is so simple a matter, the capacity is regulated by intermittent running and not by governing the speed though by proper method of delaying the ignition the same result may be obtained.

During idle periods a charge may be held almost indefinitely, without the use of any ground valves, for the exhaust valves are at such times covered with water, the admission valves for gas and air are rubber faced and the plunger is packed with a soft cup leather. Such ideal materials as rubber and leather can be used because they do not get hot, the diaphram which is between them and the fire being thoroughly cooled by the water once every stroke when in the position indicated by stage (5).

It is now entirely practicable to pump against heads of 120 ft. and upward with a material increase in speed and consequent total horsepower for a given outlay of capital. Pumps designed to work against heads between 60 and 30 ft., need have no discharge valves, because the mean effective pressure is more than sufficient to maintain discharge during the entire expansion stroke, but a set of check valves is necessary in the column, which, while permitting free flow on the power stroke, yet throttles the flow on the back stroke to that head which will give the desired compression. Pumps built to work at heads of 30 ft. or less need have no obstructions whatever in the water column.

All the valves employed are of the simplest possible type and extremely rugged constructon. Minutely accurate adjustment of individual valve springs, necessary in the case of four-cycle pumps, is avoided by employing a single control valve for the mixture. This valve also insures against backfires by cutting off the gas supply completely before the end of the charging stroke and scavenging the gas ports ahead of the admission valves with pure air, which, on the succeeding suction stroke, is first to enter the top of the combustion chamber and thus completely extinguish any lingering flame that might remain from the previous stroke.

A tubular type of water valve plays an extremely important part in the successful operation of the pump, for it has been found by test that, for the space occupied, it is more efficient for the inlet of water than any of the conventional types of water valves investigated. This same valve, placed horizontally and provided with holes on the under side to permit air within the tube to act as a cushion, is used as a discharge valve for the high-head type of pump.

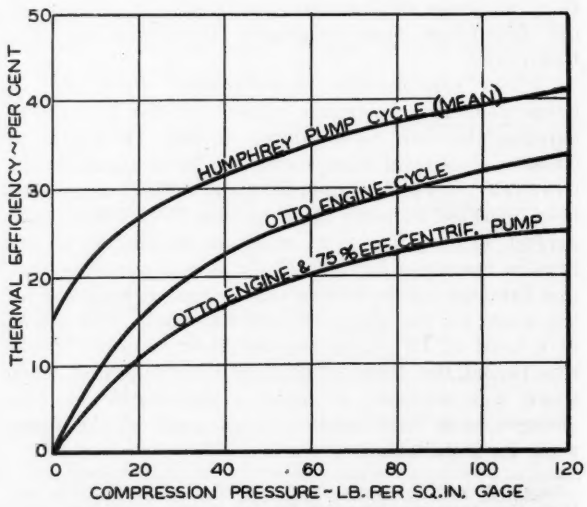



FIG. 2. COMPARATIVE EFFICIENCY CURVES

# Readers' Conference

## Simple Rule for Steam Temperature

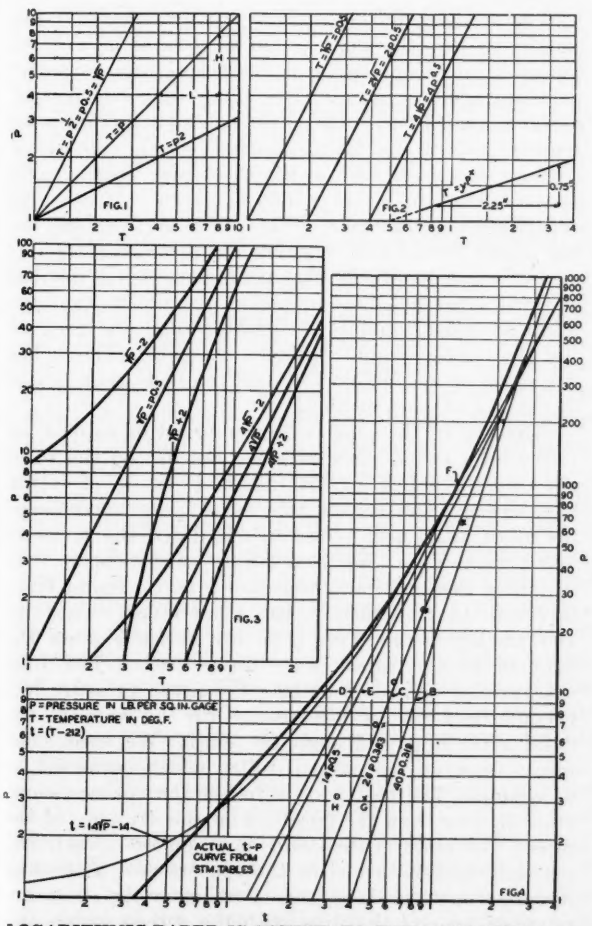
JUDGING FROM replies received from subscribers in response to the request for a simple method of estimating steam temperature on p. 151 of the March issue, the most widely used formula is

$$T = 198 + 14\sqrt{P}$$

where T = temperature in degrees Fahrenheit and P = gage pressure in pounds per square inch. Many of those answering expressed an interest in the derivation of the two constants, 198 and 14, which form an important part of the equation.

These constants were undoubtedly obtained by plotting the actual temperature-pressure curve on log paper and then finding a formula to approximate a portion of the curve. Formulas of this kind have been worked out in detail to fit the entire pressure range with considerable accuracy and can be found in steam tables or books on thermodynamics although they are quite complicated.

Simplified formulas fit only a limited portion of the curve. And their determination requires a certain knowledge of logarithmic paper. On this the usual rectangular coördinates are replaced by a logarithmic scale as shown in Fig. 1. Plotted on such scales a simple exponential function such as $T = P^x$ is a straight line as shown for $T = P^2$, $T = P$ and $T = P^{0.5} = \sqrt{P}$. The exponent x is the slope of the line, that is $x = L \div H$. Any multiple of such an exponential function such as $T = 2\sqrt{P}$ or $T = 4\sqrt{P}$ is also a straight line which is displaced to the right as shown in Fig. 2.




LOGARITHMIC PAPER IS USEFUL TO THE ENGINEER AND CAN BE USED IN MANY DIFFERENT WAYS.

In the unknown line $T = yP^x$ at the lower right hand corner of Fig. 2, the constants y and x can easily be determined. As x is equal to the slope of the line $L \div H$. This measured in the original graph is $2.25 \div 0.75 = 3$. The equation is therefore $T = yP^3$. The second constant y can be calculated by taking values of T and P from the curve and solving the equation $y = T \div P^3$, or graphically by extending the curve down until it cuts the line $P = 1$. At this point $P^3 = 1$ and $T = y = 5$ so that the complete equation is $T = 5P^3$.

Another form of equation often met with may be written $T = P^x \pm z$. Two examples of this are shown at the left of Fig. 3 as $T = \sqrt{P} - 2$ and $T = \sqrt{P} + 2$. The former gives a curve convex downward, the latter a curve concave downward. The constant z can be determined by taking values for P and T and solving for z, or graphically, by extending the curve down to where $P = 1$. A more complicated form might be written as $T = yP^x \pm z$. This is shown at the right of Fig. 3 for $T = 4\sqrt{P} - 2$ and $T = 4\sqrt{P} + 2$.

If now the temperature of saturated steam be plotted as a function of pressure a curve is obtained and (see p. 229, May, 1933) an equation $T = 135\ P^{0.2}$ obtained. It might be reasonable to assume, however, that if 212 deg. F., the boiling point of water, were used as the starting point, that there might be some simpler relation between the pressure and the increase of temperature above 212. Accordingly the heavy curve of Fig. 4 was plotted with $t = T - 212$. That is t is the increase in temperature above 212, not the temperature itself.

This will immediately be recognized as of the same form as the curve of Fig. 3 of the general form $t = yP^x - z$. By inspection of the upper part of the curve one might as a trial draw in the line B and as explained before take its equation as $t = 40\ P^{0.319}$ with $z = 40 - 3.5 = 36.5$.

If however 36.5 is subtracted from the actual temperature pressure curve, the resulting curve indicated by crosses, as at G, would be concave downward showing that Z is less than 36.5. Another trial using $Z = 24$ gives a curve indicated by the circles, as at H, which curves the opposite way, so that the most probable curve is located as curve C. In this $t = 26\ P^{.0383}$ and $z = 22.5$.

The solution of this equation requires logarithms, however, and it is not what might be called exactly simple. Furthermore it is apparent that no simple equation will fit more than a small range of pressures.

The logical thing to do, therefore, is to take a portion of the curve and try to fit it to a simple formula such as some function of $P^{0.5}$ or $\sqrt{P}$. As a start using 100 lb. gage as a good average value the curve P might be drawn through the 100 lb. point F. Plotting a few points by the cut and try method soon locates the line D as $t = 14\sqrt{P}$. Using the usual method of figuring Z when the curve cuts the $P = 1$ line, z would be $14 - 3.5 = 10.5$. It is apparent that for the sake of simplicity and to fit the more important part of the curve $t = 14\sqrt{P} - 14$ more closely fits the pressure range around 100 lb. Inasmuch as $t = T - 212$ then

$$t = T - 212 = 14\sqrt{P} - 14$$
$$T = 14\sqrt{P} + 212 - 14 = 14\sqrt{P} + 198.$$

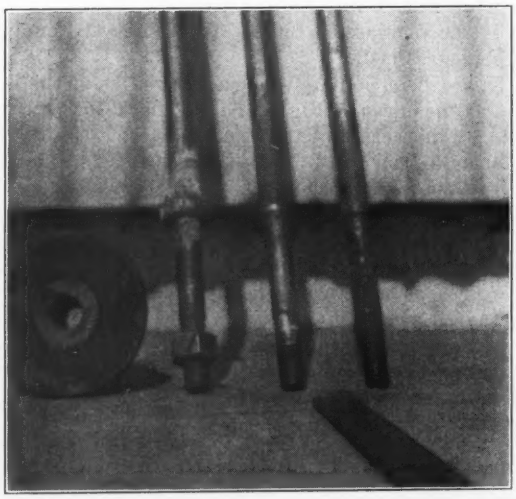
This gives a close approximation from about 25 to 125 lb. The deviation from actual conditions at high and low pressures is shown by the light and heavy curves of Fig. 4.

## Bettering Pump Rod Design

WITHIN A few weeks after replacing the bronze main rods on the piston packed pumps providing cooling water for the station's gas engines, a plainly audible thump at each end of the stroke indicated that the iron piston casting was working on the rod, permitting leakage of water through the piston and cutting down the output by almost fifty per cent.

The rods as furnished by the factory bore a small shoulder—less than ⅛ in.—against which the head was supposed to fit and on which, if effective, a seal must be maintained against water discharge pressure. At the right of the illustration appears a rod with its original shoulder; in the center is shown a similar rod after being in service long enough for the head to abrade the inadequate shoulder and begin traveling to and fro on the rod—this particular part showed ⅝ in. play before it was feasible to shut down the unit and rework.

At the left of the photograph, next to the piston head casting, appears the mate to the rod in the center, after being overhauled. The worn rod was alined in the bore of the head casting, with the abraded shoulder line as nearly as could be determined in its proper place. Then, with an oxy-acetylene torch, metal was brazed on the rod to form a shoulder averaging ⅜ in. in thickness; the face of this built-up shoulder conforming minutely to every detail of that portion of the piston head with which it was in contact during the brazing operation.



PUMP HEAD WITH REWORKED, WORN AND NEW RODS COMPARING BUILT-UP SHOULDER WITH ORIGINAL FORM

When reassembled and repacked, the pump output again reached normal, and when taken down for examination after a period of service more than four times the maximum obtained with factory made rods, the brazed shoulder was found to be as good as when built up, and no trace of internal leakage was discoverable.

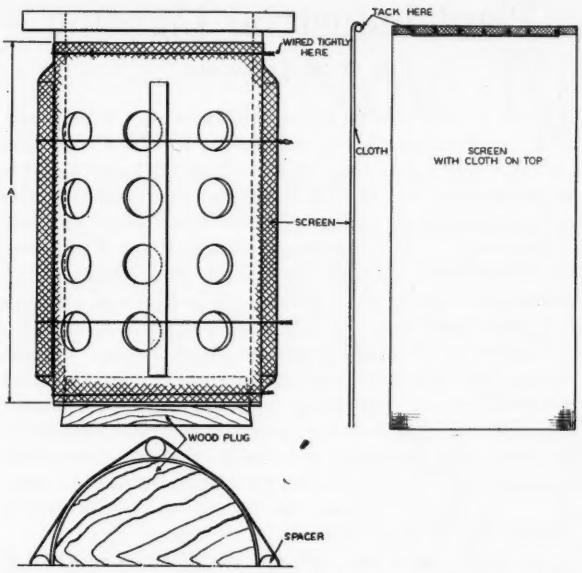
Longview, Tex. ELTON STERRETT

## Emergency Pump Strainer

IN SPITE of all that we can do emergencies do come up and the only preparation possible is an ample supply of the raw material from which to fashion something to meet the immediate need. A case of this kind came up recently in connection with construction work which was interrupted by bad weather. Rain and snow with alternate thaws caused leakage into the basement through a torn out wall. This leakage carried considerable sand and grit which got into the sump.

Fortunately the night man had presence of mind enough to stop the sump pump as soon as he noticed the sand and stopped the pump before any considerable damage was done. The sump soon overflowed, however, and started to flood the basement so that some remedy had to be found quickly so an emergency strainer was made from a length of pipe, some coarse cotton cloth and some window screen. After some experimenting with two or three different designs the one shown by the sketch was found to be best. This is made from a length of pipe through which a number of fairly large holes are drilled so as to make the area of these holes equal to or greater than the area of the pipe. Slots would probably be more effective but it was easier and quicker to drill the holes than it was to cut the notches or slots.

The end of the pipe is then plugged or capped up (we used a round piece of wood cut out on the band saw) and wrapped up with alternate layers of cotton and screen. The screen acts as a spacer and keeps the cloth apart and seems to cut down the pressure loss a great deal. We used a very coarse cotton considerably thicker than cheese cloth as we found more layers of this to be better than a few layers of heavier and thicker cloth. This probably depends upon the fineness of the sand being filtered out. The four spacers also helped in cutting down the pressure loss because they gave a free passage for the water to the holes after it got through the cloth. We used some pieces from an old curtain roller which happened to be around. The best way is to cut the spacers somewhat shorter than the length A in the drawing of the pipe. The cloth is then laid down on the screen and the ends tacked to one of the spacers just as though it were a curtain. With this as a starter the strips are wrapped around the pipe with the screen inside and the other three spacers in position. After three or




EMERGENCY STRAINER MADE FROM SCREEN AND COTTON CLOTH

four thicknesses are on, the ends are secured by a couple of pieces of wire and both ends of the pipe taken in close so that there is no leakage around the ends.

This strainer is effective, easily made and easily taken apart for cleaning and will tide one over emergencies. New cloth can be used each time although the cloth washes out very nicely with water if there is no oil on it. In that case a little kerosene or gasoline is effective in cleaning it.

Springfield, O. F. PAUL.

## Coil End Corrosion of Atmospheric Condensers

COIL ENDS of atmospheric condensers are likely to be attacked by corrosion where they are alternately wet and dry. Where the coils are completely wet or completely dry there is no trouble but corrosion always takes place where the coils are situated above water and are continually getting splashed and drying again.

In these cases the best remedy is to clean the parts of the coil subject to the splashing of all dirt and rust. Then give the surface a coat of bitumastic paint. While the paint is still wet wrap a strip of wet canvas round the coil in a spiral fashion, starting at the header and continuing along the tube to where it is always wet. When completed the canvas should be given a coat of bitumastic paint, and a second canvas layer wound on, and this layer when completed given a coat of bitumastic paint. This will be found to give the coil ends complete protection against corrosion due to the splashing water.

A cause of corrosion of the cooling coils of brine tanks is through air being carried into contact with the coils with the return flow of brine. The pipe through which the brine is returned to the tank is usually placed so that it is two or three inches above the level of the brine in the tank. As the brine falls from the return pipe into the tank it is possible that by its velocity it may carry a small quantity of air with it. This is brought into contact with the pipes which will quickly lead to corrosion.

When corrosion is traced to this cause the only remedy is to carry the brine return pipe to just below the level of the brine so that air is not picked up by the falling brine. All pipes exposed to the atmosphere of either brine tanks, or any type of condenser should be kept well painted to protect them from rusting and corrosion. Aluminum paint is effective for this work, giving excellent protection as well as a good appearance.

Herts, England. W. E. WARNER.

## Steel and Iron Identification

FROM TIME to time methods or processes have been printed for determining if a pipe is iron or steel. The majority of the methods suggested are so complicated or tedious that comparatively few engineers will go to the trouble to try out any of them.

A method that has never been in print so far as I know can be tried out by any man in one minute.

Just mix 5 drops of nitric acid with 10 drops of water, file a clear spot on the surface of the pipe that is to be tested, place a drop of the mixture on the clear spot. If the metal is steel the liquid will turn the metal surface black instantly, if the metal is wrought or malleable iron the surface will remain bright for a considerable length of time.

Toronto, Can. JAMES E. NOBLE.

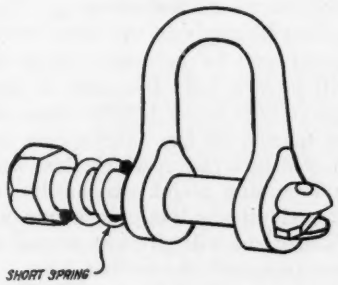
## Handy Quick Shackle Bolt

POWER PLANT men interested in handy ideas about the plant and like myself ever ready to add one to my collection can clip this one out and paste it in the old notebook.

While it is a simple stunt it makes it none the less valuable for it saves time and makes things convenient. I call it a quick hand shackle bolt, made from a common steel bolt sawed and slotted at the one end and drilled for a pin, then a small cross piece of the same width as the body of the bolt is fitted to the pin and a small section of a spring is slipped on the bolt, the sketch shows how it is both made and assembled.

For use about the plant and anywhere that a bolt that is passed through in a similar manner, such as portable work platforms, this idea can be used.

Concord, N. H. CHAS. H. WILLEY.



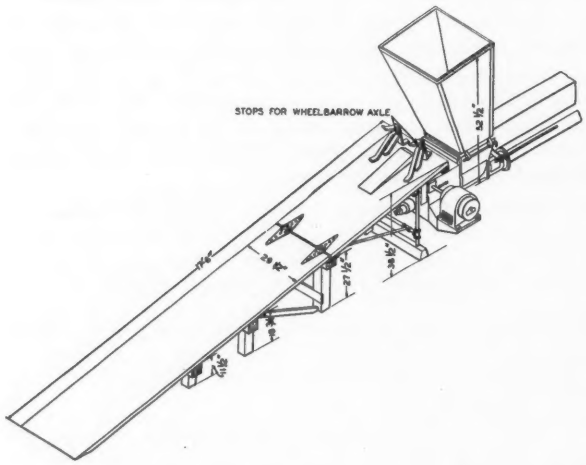

NUTLESS, QUICKLY DETACHABLE BOLT

## Labor Saving Runway for Small Stoker Plants

THE ACCOMPANYING sketch illustrates an arrangement which was devised to facilitate the delivery of coal into the hopper of a small stoker. Before this arrangement was used, the coal was dumped in front of the boilers and shoveled into the hopper by hand. This meant handling the coal twice, once when it was removed from the bins and again when it was delivered to the stoker hopper.

With the runway shown, at least half of the labor is eliminated. As may be noted the arrangement consists of an inclined runway leading to the stoker hopper. At the top, immediately in front of the stoker hopper an arrangement is provided which engages the extended axle of the wheelbarrows so that the latter may be tipped forward and the coal delivered into the stoker hopper. The runway is hinged as shown so as to provide a free passageway in front of the boiler when necessary.

Chicago, Ill. FRANK G. TABB.




## Making Connections Between Hose and Metal Pipe

CONNECTIONS made between rubber hose and metal pipe often fail and become leaky in a short time, owing to the action of the rust from the metal on the rubber. One good way to make these connections is first to clean the metal pipe where the joint will be and then tightly wrap on some rubber tape, so as to give a smooth surface, the loose end of the tape being secured to the binding by rubber cement so as to give the pipe a continuous rubber covering. The hose connection can then be made in the usual way.

As the joint will be between rubber and rubber the joint will have a long life, and if the joint has ever to be broken the break will be clean without any blistering or tearing of the rubber hose in breaking the joint. Any deterioration which does occur will be on the tape wrapping which can easily be replaced. Where the metal pipe is likely to attain a high temperature this method will prevent actual contact between the hot pipe and the rubber hose.

Herts, England. W. E. WARNER.

# Plant Industrial Lighting

BY H. S. KNOWLTON

MANY INDUSTRIAL establishments, hotels and institutions do not maintain a lighting specialist on their staffs, but look to the plant engineer and his assistants to handle illuminating problems on the rather infrequent occasions where these arise. Interest in this subject is increasing and the Plant Engineers Club at Boston recently devoted a good share of an evening to discussing practical applications of lighting in varied factories. Utility coöperation is frequently available to industrial concerns which require a plant engineering organization for economical operation and maintenance of processing and auxiliary equipment; but unless the local staff contains one or more members familiar with the basic principles of illumination and the main pitfalls to avoid in their application, the service of the group is likely to fall below the caliber it renders in the heating and power fields.

In some cities the unfamiliarity of the staff with modern ideas about lighting stands out like the proverbial sore thumb. Hotels and public libraries often reveal sub-standard practices in the selection and use of lighting fixtures, choice of lamp types and sizes, presence of glare, inadequate distribution of candle power, poor voltage regulation, inflexible switching arrangements and wasted light. A sharp eye will often detect inexcusable flickering of a nominally minute character at the sockets of establishments representing outlays running into the hundreds of thousands in architectural appearance, structure and furnishings. Poorly arranged units in lobbies may be susceptible to improvement at moderate cost in connection with the lighting of display cases, counters and other areas.

In the factory the lighting problems run through a wide range and shifts in machine locations and changes in processes give the engineer an opportunity to render useful service even if he does not possess expert knowledge of illumination. He may have little part in the original design of lighting systems, but in their maintenance he needs to qualify himself to handle the recurring problems from the engineering standpoint. A vast amount of information is available from the lighting manufacturers, and plant electricians can often be trained to utilize this effectively.

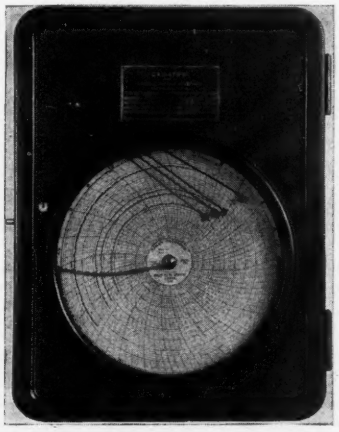
Curtailment of maintenance forces during the past few years has hampered the plant staff in its lighting service in not a few establishments, but better days are at hand. One plant engineer stated at the Boston meeting that his establishment contains 12,000 lighting fixtures, and half of these have to be maintained either from overhead cranes or from ladders more than 20 ft. long. In place of the proper monthly cleaning the gaps between this needful attention sometimes ran up to a half year or more. The point was well made that unless executives approve adequate maintenance there is little use in spending money to modernize lighting installations in industries. With the improvement of manufacturing conditions lately apparent signs of greater liberality in relation to engineering matters are not lacking, and the plant engineering force which adds a reasonable facility in lighting practice to its attainments is sure to increase its value to its employers in the days to come.

# New Equipment

## Bailey Potentiometer Pyrometer

BAILEY METER Co. of Cleveland, Ohio, announces the development of a potentiometer pyrometer named "Galvatron" because it employs a galvanometer-electronic relay circuit to operate slide wire resistances and recording pens. One Galvatron may include as many as four potentiometer circuits, the contact making galvanometer being automatically switched from one circuit to the next by relays actuated from contacts made by a synchronous motor driven time device.

The Galvatron mechanism consists of a galvanometer of short



period arranged to make contacts of a duration proportional to the deflection of the galvanometer needle from neutral. These contacts which close the circuit to the electronic relay carry only a few micro-amperes of current, and are connected to the grids of Pliotron tubes. A galvanometer contact permits the flow of direct current through one Pliotron tube and the d.c. winding of its transformer whose second winding is in series with one field coil of a reversible synchronous motor driving the potentiometer unit. This flow of direct current permits a flow of alternating current through the transformer and field coil, thereby rotating the motor in one direction. Rotation in the opposite direction is produced in the same manner by energizing the other field coil through a second electronic relay when the galvanometer needle swings to the other side of neutral.

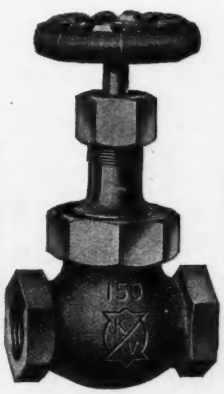
Split second operation of the reversing synchronous motors is obtained by the use of the Galvatron circuit, since the electronic relays act instantaneously in accordance with the galvanometer contacts.

Automatic standardization takes place approximately every 4 hr. at which time the dry cell is balanced against a standard cell.

An outstanding feature is its continuous record or records, up to four in number, made on a circular recording chart.

## Bronze Valves

HEAVY STANDARD BRONZE globe and angle valves are now available in a new line being offered by the Kennedy Valve Mfg. Co., Elmira, N. Y. A new departure in these valves is the cadmium plating of the malleable iron union bonnet ring and stuffing box nut. The union bonnet ring construction is made with malleable-iron bonnet ring for strength and rigidity and a bronze-to-bronze true union joint between the body and the bonnet. The special design of the bearing surface between the stem and the disc holder reduces operating effort and four guide prongs on the disc holder which prevents tipping or binding of the disc holder as the valve is opened or closed. These guide prongs also permit holding the disc holder firmly but without damage in a vise for replacement of the disc. Many additional refinements of design have been included to further improve the operating ease and economy.



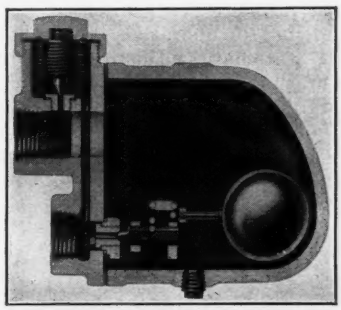

These valves are known as Kennedy Fig. 89 Globe Valve and Fig. 90 Angle Valve. They are made in a full range of sizes from ¼ in. to 3 in. inclusive and are suitable for 150 lb. working steam pressure and 250 lb. working water pressure.

## Sarco Float-Thermostatic Trap

SARCO Co., Inc., New York, in a new design of trap combining the float and thermostatic principles carries the working pressure for which this type is now available to 180 lb. per sq. in.

The trap is compact in design and light in weight so that it can be supported directly on the piping. Inlet and outlet are on the same side, a small vertical distance apart for easy connection to horizontal pipes. All working parts are on the cover and can be exposed for cleaning by removing the trap body and without disturbing the connections.

The automatic air bypass is arranged on the down-board side of the trap, so that the thermostatic element is at no time exposed to the full steam pressure. It will keep the trap vented at all times so that it cannot become air-bound.



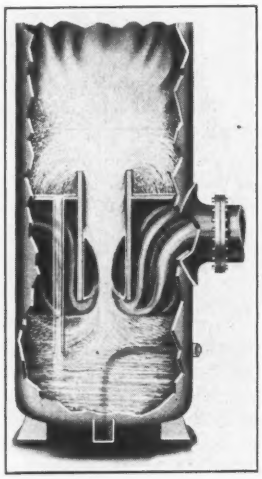
## Edward Straight-Through Valve

THE EDWARD VALVE & MFG. Co., Inc., East Chicago, Indiana, offers a forged steel valve which is known as a "straight-through" valve, being somewhat similar in characteristics, as far as straight line flow is concerned, to a gate valve. Instead of a wedge disk, the disk is a truncated cone swiveling on the end of the stem.

The valve is made in sizes from ¼ to 1 in. and fulfills the functions of a gate valve in the smaller size range. It is well suited for use on instrument lines, by reason of its sturdy construction, and is rated for 2500 lb. hydraulic pressure at room temperature and 600 lb. working steam pressure at 750 F. Carbon steel, stainless steel and "18-8" are the standard materials in which it is furnished. The inside screw type of bonnet is employed.

## The Blaw-Knox Liquid-Gas Contactor

RECENTLY developed by the Blaw-Knox Co., Pittsburgh, Pa., the Blaw-Knox Contactor is offered as a thoroughly engineered device to effect a complete mixing of gas or steam and a liquid. In this machine the gas is dynamically forced into most intimate contact with the liquid and in operation it is inherently automatic, adjusting itself instantly to changes in gas flow while maintaining the highest efficiency of contact between liquid and gas.



The contactor is particularly well adapted to the following types of work:

Desuperheating — meaning the automatic elimination of superheat from steam, regardless of changes in flow or amount of superheat.

Gas and air cleaning, including the scrubbing of exceedingly fine dust from gas.

Gas cooling—in one, two or three stages in a single shell.

Gas or air hydration in a single stage, affecting complete saturation of the air or gas stream.

Oxidation, chlorination, aeration and allied problems — where the extreme intimacy of contact effected, speeds reactions and increases through-put.

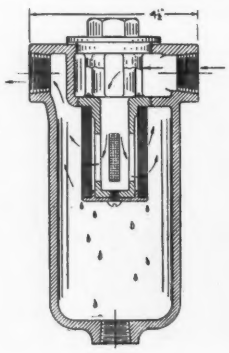
Absorption problems, which theoretically require not more than three trays or stages of contacting.

Operation is not critical. Gas or vapor rates may vary over a wide range. Any desired ratio of liquid to gas can be maintained. Heavy fluids, even slurries, may be thoroughly contacted with a gas or vapor. The unit may be used on either continuous or batch processes.

## Gast Steam Separator

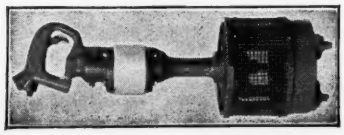
DEVELOPED as a modification of the Gast compressed air separator, the Gast steam separator recently placed on the market retains the principle of zigzagging the moisture laden vapor through several layers of coarse screens. The comparatively large effective area of the screen plus the space between ports and screen permits the separator to function also as a strainer for long periods without cleaning, although removal for cleaning is easily accomplished.

This new product of the Johnson Corp., Three Rivers, Mich., is made in sizes from ½ to 2 in. and is intended for application on individual steam lines serving heat transfer and process equipment such as presses, ironers, cooking kettles, heaters and dryers.



## Air Tool Polishes Tube Ends

CHICAGO PNEUMATIC TOOL CO., New York City, has placed on the market a pneumatic tool driven by a rotary type motor for the special purpose of polishing tube ends before they are installed in boilers. The entire tool weighs 24 lb., is easily handled and tends to



round the outside of the tube. The polishing is done by renewable carborundum sticks that travel around the end of the tube, being held in position by four pilots that bear against the outside of the tube.

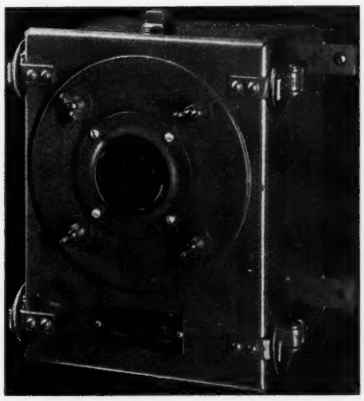
## Acree pH Meter

AMERICAN INSTRUMENT CO., Washington, D. C., announces a line of compact and convenient electrode assemblies for pH work, in which a calomel reference cell and unknown chamber are combined in one piece of glassware. An especially convenient assembly is the one in which either glass, hydrogen, or quinhydrone electrode can be used, which requires a sample of any 2 to 10 cc. of liquid.

These electrodes were designed for use with the new Acree pH Meter, but can be used as well with any potentiometer set-up for that type of electrode. The Acree Universal pH Meter is adapted to use with glass, hydrogen, quinhydrone, or antimony electrode, and with any type of solution, including colored, very dilute, weakly buffered, oxidizing or reducing, and colloidal solutions.

## Light Source for Phototube Controllers

WESTINGHOUSE ANNOUNCES the Type E Light Source for use with light sensitive equipment. It is especially useful in those applications requiring transmission of the light beam over a considerable distance or in others where the light beam must penetrate steam, dust or similar semi-translucent substances such as encountered in steel mills and still retain enough intensity to operate the light sensitive control reliably. An intensity of 24 footcandles is obtained at 25 ft. An intensity varies inversely as the square of the distance for other distances.

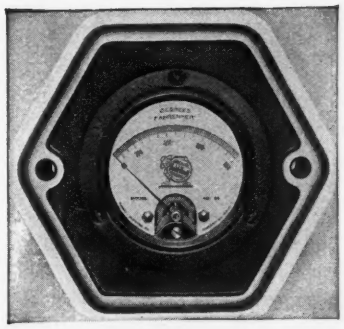


The Type E Light Source consists of an industrial light source lamp rated at six volts, five amp. and 3000 hr. life and a lens for condensing the light rays into a nearly parallel beam. Provisions are included for adjusting the focus of the lens with respect to the lamp so as to locate the beam easily at the desired spot without removing the cover of the unit. A transformer is included so that the lamp can be operated from any commercial source of power except direct current. The whole assembly is mounted in a steel cabinet suitable for either indoor or outdoor mounting.

An infra red filter to provide an invisible light beam is an optional accessory.

## Hold-Heet Pyrometers

DEVELOPED as an individual instrument applicable to every type of heat machine, the Russell Electric Co., Chicago, Ill., has placed on the market the Hold-Heet pyrometer. The instrument is of the direct reading type with manual cold end correction adjustment,



combining accuracy with a rugged and durable construction. The instrument employs heavy gage thermocouples without connection leads which results in an extremely low external resistance and a comparatively large current flow.

In the power plant the instrument is conveniently applicable to indicating such temperatures as that of stack gases, superheated steam, oil engine exhaust, preheated combustion air or other important temperature conditions in the range between 60 and 1600 deg. F.

## Nason to Make Detroit Traps

THE NASON MANUFACTURING CO., New York, is now exclusively manufacturing the full line of Detroit steam traps, including the return, vacuum, combination and separating traps, and also the Detroit receiver. The principle of the Detroit trap is an arrangement of valves, actuated by a tilting tank through an arrangement of levers.

Tank, mounted eccentrically, on hollow trunnion, is held in horizontal position when empty, by means of large counterweight. When tank fills with water through hollow trunnion, counterweight is over-balanced and tank tilts, actuating the valves.

## Large Cranes for Boulder Dam

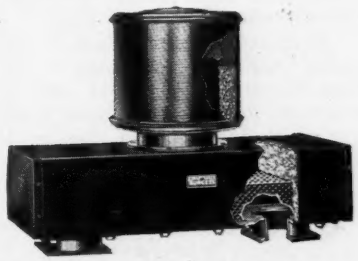
THE LARGEST award in the electric crane industry in the past five years has just been announced as the contract for five electric traveling cranes is confirmed to the Harnischfeger Corporation from the United States Reclamation Engineer's Office in Denver, Colorado. Total amount of the contract is approximately a quarter of a million dollars involving construction of four 300-t. cranes and one 50-t. crane. The four 300-t. units are equipped with two 30-t. auxiliary hoists. They are of the double trolley power house type, having a span of 64 ft. and a lift of 70 ft. The eight electric motors employed in the bridge drive, the hoist and hoist propel mechanisms, are the Harnischfeger special crane type, having a combined output of 380 hp. for each crane. The truck bodies and trolley frames are to be of welded construction.

After the cranes have been completely erected and tested in the Harnischfeger shops, they will be completely dismantled for shipment to Boulder Dam. A 150-ton cableway which spans the Colorado Canyon will lower the huge units to the floor of the power house, approximately 600 ft. below the brink of the canyon.

Two of the 300-t. units will be installed in each wing of the power house for the purpose of handling the huge generator rotors, which have a diameter of 26 ft. and weigh approximately 600 t. each.

## Combined Silencer and Air Cleaner

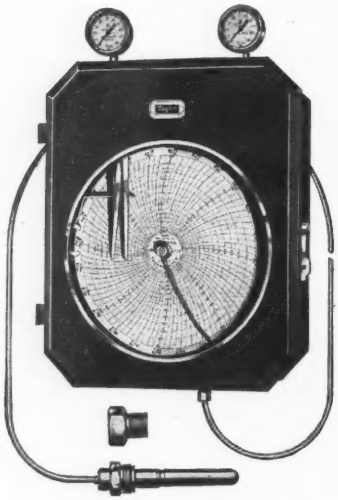
BURGESS BATTERY CO., Madison, Wis., has just announced a combined intake air silencer and cleaner which not only traps and absorbs intake noises, but filters grit and dust from the air. The silencing unit



is built on the same principles as Burgess straight-through mufflers, but the air cleaner represents a new development, using cellulose fiber saturated with oil. The fibers hold a volume of oil which feeds out due to the capillary action of the dust and dirt as it accumulates, thus maintaining efficiency.

## Recording Regulators

TAYLOR INSTRUMENT COMPANIES, Rochester, N. Y., recently announced the Fulscope, a newly designed line of air-operated recording regulators for temperature, pressure, rate of flow, or liquid level. The temperature or pressure regulators are readily adaptable to applications requiring a different temperature or pressure range by substituting a tube system and chart of the required range. It is equally easy for the operator to convert a temperature instrument into a pressure instrument, or vice versa.

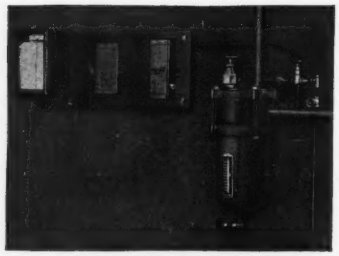


A simple screwdriver adjustment and a graduated dial give throttling, or on-and-off diaphram valve action, whichever is the desired type of control. No alterations are required to the mechanisms of these instruments to operate in conjunction with Taylor Dubl-Response control unit which may be required if precision control is imperative despite extremely difficult operating conditions.

Regulators are supplied in two styles: for face-mounting, or for flush-mounting on panel boards. Standard finish is instrument black but white finish can be supplied if desired.

## Boiler Concentration Meter

IN ORDER to help better the economy of operation of large boilers and to protect the blading of turbines, the Esterline-Angus Co., Indianapolis, Ind., has developed an instrument to make a continuous record of the salt concentration in boilers. This recorder consists of two units, the pressure



reducing chamber and the recorder. The boiler is tapped below the water line and a pipe is carried from this opening to the needle valve on the reduction chamber. As the water enters the chamber the pressure is reduced to atmospheric, the upper part of the chamber having a free opening.

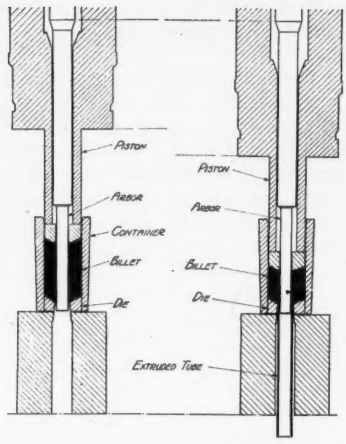
The recorder is a standard graphic ohmmeter. When connected to a 110 or 220 volt a.c. circuit and to the electrode mounted in the reducing chamber, it records the resistance of a fixed column of the water as it comes from the boiler. There is a definite relation between the ohmic resistance of a column of water and the percentage of any salt held in solution. The recorder can be furnished in either portable, wall and front or flush switchboard cases and are supplied with either spring driven or synchronous motor chart drives.

## Extruded Condenser Tubes

EXTRUDED, ROLLED and DRAWN condenser tubes are now in commercial production by The American Brass Co., New York., N. Y., and are available in standard and special alloys. The trade name is the Anaconda Extruded Condenser Tube. Extruded tubes are produced by extruding cast billets which previously have been machined to remove surface irregularities. This assures perfectly clean surfaces, inside and out, free from foreign matter and defects. The mechanics of the operation are shown in the sketch.

After extrusion, the tube is cold swaged-rolled on a mandrel then finished by annealing and cold drawing and given a final low temperature electrical anneal to insure a fine and uniform grain structure.

The extrusion process is employed by The American Brass Co. in the production of both brass and copper-nickel alloy tubes, with the same physical results. Extruded tubes are available in Anaconda Super-Nickel, 70 per cent




copper and 30 per cent nickel; Ambrac Metal, 75 per cent Copper, 20 per cent Nickel and 5 per cent Zinc; Aluminum Brass, 76 per cent copper, 22 per cent zinc, 2 per cent aluminum, and Admiralty Metal.

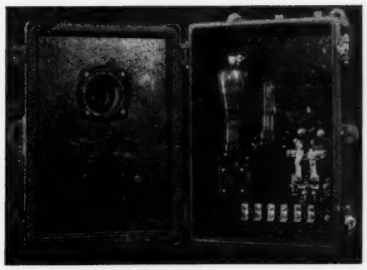
## Condenser Tube Cement

FOR THE PURPOSE of protecting condenser tubes from erosion and corrosion, the Debevoise Co., 968 Grand St., Brooklyn, N. Y., has placed on the market Debevoise condenser tube cement. Although intended primarily for condenser tube service it is also applicable to condenser tube sheets, pump impellers and other moving parts submerged in water.

As applied to condenser tube service the cement is applied as a paint with a swab to about 8 or 10 in. at the inlet end of the tube. The cement dries in 3 or 4 hr. Experience in one of the large utility plants shows that a gallon of the cement will cover the ends of about 4000 tubes and that the coating should be repeated every 4 to 6 mo.

## A New Photo Troller

WESTINGHOUSE ANNOUNCES the RK Photo-Troller especially adapted to industrial light sensitive applications requiring operation on low light intensity. The indoor model operates on three footcandles with the phototube extended at distances up to ten feet. The unit will operate on as little as one-half footcandle with a pick-up lens such as is available on certain indoor and all outdoor models. The unit combined with standard light sources will cover up to a 50-ft. throw. Invisible beams from standard light sources operate the RK units at 20 ft.



The RK Photo-Troller is unusually rugged as the phototube operates the grid glow tube which in turn closes the contactor. No delicate intermediate relays are required. Both tubes used are of the industrial type, designed for ruggedness and long operating life.

The contactor is provided with make and break contacts to obtain any operation sequence desired. The contacts will carry 20 amperes at 115 v. or 15 amp. at 220 v. alternating current. Speeds of operation as high as 300 per min. are obtained.

The RK Photo-Troller is available for all commercial sources of power except direct current.

## A.S.M.E. Semi-Annual Meeting

ANNOUNCEMENT is made by the American Society of Mechanical Engineers that the Semi-annual meeting will be held this year on June 25 to 28 at Denver, Colo., with headquarters at the Cosmopolitan Hotel.

Two papers will be presented on Monday morning in the first session, one on passenger tramways and the other on smoke problems. Monday afternoon will be taken up with inspection trips. In the evening there will be a series of lectures with motion pictures giving a story of the work at Boulder Dam. An interesting exhibit in the hotel lobby will be arranged showing the important reclamation projects.

Tuesday morning two simultaneous sessions will be conducted, one on heat engineering covering air conditioning, experiences in the burning of pulverized lignite and petroleum coke. The other will be an informal round table discussion arranged by the Management Division on the subject of decentralization of industry with particular reference to its effects in the West. The afternoon will be given over to inspection trips and another round table discussion under the auspices of the Management Division, the topic of which will be the first year of industrial management under the NRA. A semi-formal banquet with addresses by the President of the Society, Col. Paul Doty, and an unusual address by Capt. Pat O'Hay will be held in the evening of Tuesday.

Wednesday morning the papers to be presented will include a discussion of beet sugar manufacturing, mining in Colorado and a description of a unique example of coöperative manufacturing. The other session, held simultaneously, will cover recent progress in high speed, light weight railroad trains.

## Advancement of U of I Faculty

PROFESSOR MELVIN L. ENGER, a member of the University of Illinois faculty since 1907 and head of its Department of Theoretical and Applied Mechanics since 1926, was named dean of the College of Engineering and Director of the Engineering Experiment Station of the University, by the Board of Trustees. Arthur Cutts Willard who was recently elected President of the University, has been serving as Acting Dean of the College of Engineering this year.

To fill the vacancy caused by the election to deanship of Enger, Professor Fred B. Seely, a member of the faculty since 1909, was named the Theoretical and Applied Mechanics Department head. Another vacancy, caused when president-elect Willard was promoted last fall to the engineering deanship, was also filled by the Board when it named Professor O. A. Leutwiler to head the Department of Mechanical Engineering. Willard was for years head of that division. Leutwiler has been a member of the engineering faculty since 1903 and has been professor of mechanical engineering since 1921.

All three of the new appointees hold degrees from the University of Illinois. All will assume their new duties July 1.

Dr. R. D. Carmichael, who has acted as dean of the Graduate School during the present year, and Dr. M. T. McClure who has served as acting dean of the College of Liberal Arts and Sciences for the same period, were both promoted by the Board to full deanships.

## W. S. Lee Dies

W. S. LEE, vice-president and chief engineer of the Duke Power Co. of Charlotte, N. C., and president of the W. S. Lee Engineering Corporation of New York and Charlotte died March 24, 1934. Mr. Lee was a well known figure in the power plant field and during his life was identified with many large power plant developments, particularly those of a hydroelectric nature. One of his last big projects was the Beauharnois development on the St. Lawrence River which will have an ultimate capacity of 2,000,000 hp. Mr. Lee was born at Lancaster, S. C., Jan. 28, 1872. He attended the Citadel Military College of S. C., and was given the degree of C. E. in 1894. He was a pioneer in high tension hydroelectric power development and electric transmission and was the inventor of the "Lee pin." He was a member of the A. S. M. E., the Am. Soc. of C. E., the Engineering Institute of Canada, and the A. I. E. E., having served as president of the latter.

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ALFRED J. JUPP, a Vice-President of the Lunkenheimer Company, Cincinnati, died suddenly in Roosevelt Hospital, New York, April 10, 1934, while on a business trip. Born in Cincinnati June 25, 1875, Mr. Jupp entered the employ of the Lunkenheimer Co. in May, 1890. Mr. Jupp was active in the Manufacturers' Standardization Society and also contributed the greater part of his time during recent months to code work in the Valve and Fittings Industry.

EDSON OLIVER SESSIONS, consulting engineer of Chicago, died April 15 following an operation. Mr. Sessions was born in Louisville, Ky., 63 yr. ago. He was a graduate of École de Polytecnic, Paris, and was president of the E. O. Sessions Co., Limited. During the war he was an official of the United States shipping board. In 1931, at the invitation of the soviet government, he spent several months in Russia in extensive studies. He recently completed an engineering analysis of several projected soviet industrial plants.

STEPHENS-ADAMSON MFG. CO., Aurora, Ill., has reopened sales-engineering offices at Pittsburgh and Huntington, West Va. The Pittsburgh office is located at 1206 Gulf Bldg., and is under the supervision of Harry W. Banbury who has long been associated with the firm as purchasing agent and special sales engineer. The Huntington sales and engineering will be handled by D. W. Allen, a tipple and conveyor expert with years of experience in the West Virginia district.

FLAME TEMPERATURES in an Internal Combustion Engine Measured by Spectral Line Reversal written by Albert E. Hershey and Robert F. Paton has been issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as bulletin No. 262.

This bulletin describes direct measurements of instantaneous temperatures in an engine cylinder by an optical method. Maximum flame temperatures are found to vary from 3750 deg. F. abs. with the leanest and the richest air-fuel mixtures up to 4450 deg. with an absolute air-fuel ratio of 13.9 to 1. Throughout the normal operating range the observed maximum flame temperatures were approximately 600 deg. F. lower than the calculated temperatures.

# News From the Field

THE DARCOID CO., Inc., New York City, announces the removal of its office to 200 Varick St., New York City,

F. PAUL ANDERSON, dean of the College of Engineering at the University of Kentucky since 1917 and nationally known in the development of heating and ventilating engineering, died Sunday, April 8, after a long illness of cancer. He was 67 yr. old. Dean Anderson came to the university in 1891 and established engineering training as a definite part of the university. He was trained primarily to be superintendent of Studebaker Brothers' Manufacturing Co. at South Bend, Ind., where his father had been superintendent.

Dean Anderson served 4 yr. in machinist apprenticeship, he received a bachelor's degree in engineering from Purdue University in 1890 and was a fellow at Purdue in 1890 and 1891. In 1896 he did the first X-ray work done in America. That same year he developed a hauling chart for loading locomotives. For 25 yr. he was engineer of tests for the Southern Railway Co. In 1921 he was appointed director of the research laboratory of the American Society of Heating and Ventilating Engineers and in 1927 he became president of that society.

CONSULTING AND RESEARCH ASSOCIATION, Wilkinsburg, Pa., has recently been organized by five research engineers formerly employed in the Westinghouse Research Laboratories. The purpose of this organization is to provide a consulting, research and development service to manufacturing companies in the following subjects: Air conditioning, heating and ventilation, construction and application of electronic devices, oscillographs, television, electric circuits, radiography, mechanical design and application, and plant survey and layout.

BATT L. SPAIN, who has been for the past 24 yr. with the General Electric Co. at the West Lynn works as manager of turbo-blower sales, is now connected with Ingersoll-Rand Co. as Manager of the Turbo-Blower Department. He will be located at the General Offices, 11 Broadway, New York. The occasion for the transfer of Mr. Spain is the acquisition of the Turbo-Blower business of General Electric by Ingersoll-Rand Co.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., announces the appointment of B. F. Bilsland as Manager of the Chicago District Office, located at 20 North Wacker Drive, also Arch J. Cooper as Assistant Manager of the New York District Office, 50 Church Street, of which A. F. Rolf is District Manager.

EMILIO N. MACKINNEY has been appointed sales representative of Sarco Co., Inc., New York City, for Mexico City. Mr. MacKinney is a Mexican, educated in the United States, and a graduate of the Massachusetts Institute of Technology. He and his associates will handle the full line of Sarco steam specialties.

THE WALSH REFRACTORIES CORP., St. Louis, Mo., announces the purchase of the plant and clay properties of the North Missouri Refractories Co. (formerly Missouri Fire Brick Co.) located at Vandalia. The acquisition of this plant will give the Walsh Corp. a modern tunnel kiln plant for producing their high quality fire brick and refractory shapes. This plant will be operated in conjunction with the St. Louis plant, which plant will be devoted to the manufacturing of glass house refractories, high temperature cements, and other refractory specialties. The St. Louis plant has been operated by the Mississippi Glass Co.—Walsh interests—for over 50 yr.

WILLIAM F. SAILER, formerly with Alco Products, Inc., and The Griscom-Russell Co., has recently made connections with Steel and Tubes, Inc. He will be located in the Brooklyn office and will concentrate his efforts on the oil refinery and marine fields.

THE SUPERHEATER CO., New York, announces that the following of their agents for stationary superheaters, economizers, furnace water walls and other Elesco steam plant equipment have now been appointed sales agents for Ljungström air preheaters: Combustion Equipment Co., Kansas City, Mo.; F. J. Hearty, San Francisco, Calif.; Walter Castanedo, Inc., New Orleans, La.; J. W. Eshelman, Birmingham, Ala.; J. S. Cothran, Charlotte, N. C.; Rees V. Downs, Memphis, Tenn.; Haylett O'Neill, Houston, Texas, and Joy and Cox, Inc., Denver, Colo.

R. E. Chase & Co., Seattle, Wash., and Tacoma, Wash., sales agent for The Air Preheater Corp., has now also been appointed by The Superheater Co. as sales agent for Elesco steam plant equipment.

ROBINS CONVEYING BELT CO. has appointed two new sales agencies—one in charge of Fred Bathke, St. Paul, Minn., who will handle Robins' products and services in the state of Minnesota, the western part of Wisconsin and the northwestern corner of Michigan; the other in charge of Raymond Church, Pleasant Ridge Station, Cincinnati, O., whose territory will include the southwestern part of Ohio and southeastern part of Indiana, and the western part of Kentucky.

DONALD R. DOHNER, formerly Director of Art in the Engineering Dept. of Westinghouse Electric and Manufacturing Company, and Alexander J. Kostellow, Professor of Industrial Design, Carnegie Institute of Technology, have established offices at 99 Vandergrift Building, Pittsburgh, where they will carry on an industrial design and research service.

JOHNS-MANVILLE, New York City, announces a new and improved Superex insulation block which will safely withstand temperatures up to 1900 deg. F. This increase in temperature resistance has been effected by the use of a special calcined diatomaceous silica, bonded with asbestos fiber. It is particularly adapted to the insulation of high temperature boiler furnaces.

JAMES H. FERRY was recently appointed vice-president and chief engineer of Potomac Electric Power Co., Washington, D. C. He succeeds L. E. Sinclair, who is now acting in the capacity of consulting engineer for the company

L. C. WELCH, formerly manager of the lubricating department of Standard Oil Co. (Indiana), has been made assistant general manager in charge of the lubricating and technical departments, the change taking place April 1. Mr. Welch will continue to exercise general supervision over all sections of these two departments. With this change C. O. Wilson, who has been assistant manager of the lubricating sales division, became manager of the lubricating department and industrial sales. L. G. Campbell, formerly assistant manager of lubricating bulk sales, became manager of lubricating bulk sales. J. Clay Lee, assistant manager of railway sales, became manager of railway sales.

EDWARD W. JONES, 45, Vice-President and Manager of Laclede Stoker Co. of St. Louis, Mo., died March 24 after an illness of three weeks. Mr. Jones' entire life had been devoted to the power industry. After graduation from the University of Illinois he was associated with Commonwealth Edison Co. During the war he was power engineer for the American Tar Products Co. In 1919 he became associated with Laclede-Christy Clay Products Co. in the capacity of chief engineer. Early in 1924 Mr. Jones organized the Laclede Stoker Co. which acquired the chain grate stoker business of Laclede-Christy. He was a member of the American Society of Mechanical Engineers.

# For the Engineer's Library

CENTRIFUGAL PUMPS, TURBINES AND PROPELLERS. By Wilhelm Spannhake, published by The Technology Press, Massachusetts Institute of Technology, Cambridge, Mass. Size 6 by 9 in., cloth bound; 323 pages; price $5.00. Translated from the German by John B. Drisko.

This book is a valuable addition to the English textbooks on hydraulics. Wilhelm Spannhake, professor of hydraulic engineering at Technische Hochschule Karlsruhe in Germany and recently visiting professor in hydraulics at Massachusetts Institute of Technology, is well known in this country for his original work on centrifugal pumps and more recently on cavitation. The present text makes available Professor Spannhake's treatment of the fluid mechanics of rotary hydraulic machinery and machinery lectures at Massachusetts Institute of Technology.

It is a text rather than a handbook. Its primary function is to enable the reader to understand the operation and operating characteristics of existing machines by a presentation of fundamentals. It does not purport to present in detail all the knowledge and experience derived from the field of turbo-machines but to show the reader how to apply general knowledge to explain the peculiarities of

the individual machine, how to progress in problems of special fields and to correlate particular experiences and trace them back to more general knowledge.

Although fundamental, the treatment is of necessity mathematical and requires a definite working knowledge of the calculus. In the preface to the German edition, Professor Spannhake says that the first volume will be supplemented by a second volume on Application of Basic Theory and by a third volume on the treatment of Mechanical Construction of Turbo-Machines.

A. S. H. & V. E. Guide. Published by the American Society of Heating & Ventilating Engineers, 51 Madison Ave., New York City. Size 6 by 9 in., 60 pages, flexible cloth cover. Price $5.00.

This year the 12th Edition of the Guide comes out in a new cover design with new typography and with a great deal of new technical data. The 42 chapters in which the book is divided cover all phases of heating and ventilating practice, much space being devoted to air conditioning and cooling, perhaps the most active field of engineering at the present time. In addition to the technical data there is a 77-page catalog section and a 56-page membership list.

The "Mechanical World" Electrical Year Book, 1934. 304 pages, size 4 by 6 in. Illustrated, cloth. Published by Mechanical World and Engineering Record, 31 King Street West, Manchester, England. Price 1/6 net.

In this edition of a very popular handbook for electrical engineers and all users of electrical machinery and plant, a complete rearrangement of the contents has been effected which will greatly facilitate reference and systematic annual revision. Almost every aspect which interests the industrial user of electricity is treated in detail, and the whole of the subject matter has been very thoroughly revised and brought up-to-date.

Steam plant errors. By Frank H. Browning. First edition; size 4 by 6 in., 76 pages, paper cover. Published by The Stepler Company, Seattle, Washington, 1933. Price 80 cents.

It is commonly assumed that the licensed engineer in charge of power equipment is master of every situation, that at critical times he will react to every emergency properly and intelligently, that he will, intuitively, do the right thing at the right time. Doesn't it say that he is a "qualified" engineer right on his license?

That this is not so is eloquently expressed in this little booklet by Frank Browning. The mere fact that a man has been exposed to the atmosphere of a boiler room and by dint of sheer effort has managed to answer a set of standardized license examination questions more or less successfully does not instill in him the qualities to act correctly in time of emergency. He may know something about the construction of equipment and he may be familiar with the elements of routine operation but such knowledge does not provide him with the ability to forestall conditions which operators never experienced. Far more important than a catalogued knowledge of the construction of equipment is a thorough knowledge of fundamentals coupled with an understanding intelligence and an alert mind.

Skillfully and amusingly Mr. Browning discloses the important principles of boiler operation. In doing so he presents an unusually penetrating analysis of the average license applicant's mind and store of knowledge. As the Engineer-examiner for the City of Seattle, Washington, he is well qualified to do this. Years of personal contact with men applying for licenses has given him not only an excellent insight into their shortcomings but has demonstrated to him the weaknesses of examining methods.

As he points out in this booklet, nobody can realize the extent of unreasonable notions among steam men unless he has discussed these subjects with them. The utmost confusion exists regarding the simplest matters. What knowledge they have consists, for the most part, of scattered facts, hearsay, things which others have told them and which they have accepted dogmatically without ever presuming to question their inherent truth.

Although the booklet appears to consist of a series of questions and answers. it is not a catechism of the conventional type. The material is presented in the form of a series of dialogues between the examining engineer and the license applicant. It shows the pattern of thousands of talks with men in the field and analyzes the commonest practices, absurd notions and natural impulses, not destructively but constructively. It is intensely interesting and it is difficult to resist reading it from cover to cover at the first reading. Though a small booklet, it is well worth the 80 cents asked for it.

Mr. Browning possesses an uncanny ability to draw out the candidates' grasp and judgment. After the old examining board was discarded by amendment of the Seattle charter, he was the only man qualified in a nationally competitive examination for the engineer examiner. He is an enthusiast on reducing problems to simplest terms by detailed analysis of conditions until a definite insight is obtained, making full use of available facts without recourse to blind experiment. Although rather critical of professional men who do not utilize their facts and training, he has a sincere regard for competent operators, skilled mechanics, engineers and alert workmen. Years of experience in this work have won him a reputation for fairness, practical sense and integrity.

Plibrico Jointless Firebrick Co., Chicago, Ill., has just issued a new catalog covering Plibrico Jointless Firebrick and other refractory products which contains a great deal of information of value to engineers faced with the problem of building up or relining boiler furnaces.

A new 8-page publication describing the new Westinghouse Surge Proof Transformers has been released by the Westinghouse Electric and Manufacturing Company. Describing the advantages of this transformer, the publication includes a circuit diagram, overload curves, current-time characteristic curves, mounting methods, and constructional features.

"Improving Power Factor for Profit" is the title of Bulletin GEA-77F (superseding GEA-77E) recently issued by the General Electric Co. This bulletin, a 28-page illustrated publication, is devoted specifically to the application of G. E. pyranol treated capacitors in the improvement of power factor. The various types available are described together with full data on construction and price. The latter part of the book discusses the methods used in calculating power factor correction problems.

Bulletin GEA 1520-B (superseding GEA 1520-A)) just published by the General Electric Co. is devoted to Electric Heating Units and Devices. In it are given the answers to hundreds of small heating problems that arise daily in industrial plants to puzzle engineers, superintendents, owners and maintenance men. It is unusually informative and well illustrated. Detailed data on all the various heating devices available is presented.

Flue Gas Conductors, such as stacks, breechings and smoke jacks, made of commonly used metals are rapidly affected by the corrosive conditions encountered. Wrought iron successfully withstands severe corrosion and its use as flue gas conductors has recently been made the subject of an engineering survey by the Engineering Service Department of the A. M. Byers Co., Pittsburgh, Pa. This 44-page report points out the principal causes of corrosion and suggests economical means of increasing the useful life of flue gas conductors. Service records and photographs of wrought iron installations are given and the latter part of the report has suggested specifications for wrought iron smoke conductors of all kinds.

Belt-driven, direct-connected and steam-driven refrigeration compressors of the horizontal single-stage type are described in a 6-page bulletin recently issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

Fulton Sylphon Co., Knoxville, Tenn., is distributing a folder describing a steam water mixer designed to maintain automatically a constant temperature of delivered water even with varying initial temperature or rate of flow.

C. B. Hunt & Son, Salem, O., in its latest bulletin describes a new type of air operating valve, the principle of which has been tried in actual service for more than 3 yr., although some types now available have been developed within recent weeks.

The Horsburgh & Scott Co., Cleveland, O., has issued its general catalog No. 34 dealing with industrial gears and speed reducers which is published in the form of a handbook of general and specific information on gears and is filled with useful formulas, tables of dimensions, ratings and prices, diagrams and descriptive material.

Pennsylvania Pump & Compressor Co., Easton, Pa., in its bulletin No. 223 describes the Penn-Motor pumping units which are built in compact form for capacities from 5 to 175 g.p.m.

Data on Plug Valves with gate valve face to face dimensions so that they are interchangeable with gate valves without piping changes are described in a 6-page circular No. 3B prepared by the Walworth Co., New York City.

Some of the construction features of single stage steam turbines made in 11 frames available to meet every logical single stage turbine application are described in bulletin 1920-E which has just been published by the Moore Steam Turbine Corp., Wellsville, N. Y.

Allis-Chalmers Co., Milwaukee, Wis., has issued its Bulletin No. 1155 dealing with motor-generator sets, the services to which they are put, construction features of the motors and generators employed, frequency changer sets and sets of special construction.

The Gardner-Denver Co., Quincy, Ill., has issued a new bulletin AC-7, and new prices, on its line of air-cooled compressors and outfits. In addition to the usual description of compressors, the bulletin gives information about car washing pumps and air cooled compressors for Diesel and gas engine starting. Bulletin HAC-36 also recently issued illustrates and describes its duplex two-stage horizontal compressors.

# Power Plant Construction News

**Calif., Burbank**—Lockheed Aircraft Corporation plans installation of electric power equipment in new additions to airplane manufacturing plant. Company is arranging for a stock issue of $250,000, considerable part of proceeds to be used for expansion purposes.

**Calif., Emeryville** — Oliver Tire & Rubber Co., 4343 San Pablo Avenue, manufacturer of tires and rubber goods, plans installation of electric power equipment in new one-story mill addition. Entire project will cost about $35,000. W. Adrian, 417 West Market Street, San Francisco, Calif., is consulting engineer.

**Calif., Hammonton**—Yuba Consolidated Gold Fields, Inc., Hammonton, plans new electric power substation for power service at mining properties. Cost about $65,000, with equipment.

**Calif., Lodi**—Bear Creek Vineyard Association, Lodi, L. K. Marshall, head plans installation of electric power equipment in new winery in vicinity of Haight Station. A boiler plant will be built. Entire project is estimated to cost about $60,000.

**Calif., Stockton**—Hormovita Corporation, care of Victor Leonardini, 343 South Sutter Street, recently organized, plans installation of electric power equipment in new distilling plant at Roberts Island Road and San Joaquin River. A one-story power house and pumping plant will be built. Entire project will cost over $200,000.

**D. C., Washington**—Conrad H. Reid, Southern Building, is at head of project to construct a new two-story refrigerating plant at rear of 1114-16 Connecticut Avenue. Guy T. Scott, 4615 Nebraska Avenue., N. W., is interested in project, estimated to cost over $30,000, with equipment.

**D. C., Washington**—Potomac Electric Power Co., Washington, has plans for new one-story power substation at Thirteenth and D Streets, N. E., reported to cost about $50,000, with equipment. A building permit has been issued.

**Ill., Chicago**—Hurley Machine Co., West Cermak Road and South Fifty-fourth Avenue, manufacturer of electric washers, ironers, etc., plans installation of power equipment in new one-story addition, about 40,000 sq. ft. floor space. Cost over $60,000, with machinery. Plans have been filed for new unit.

**Ill., Danville**—Veterans' Administration, Arlington Building, Washington, D. C., will receive bids until May 8 for new ash conveyor system in power plant at institution at Danville, as per specifications on file.

**Ind., Lawrenceburg**—O'Shaughnessy Brothers, recently organized by William and Eugene O'Shaughnessy, Lawrenceburg, plan installation of electric power equipment in new local distilling plant on 20-acre tract of land. Plant will consist of several units, with one-story boiler house. Entire project will cost over $150,000. Hillsmith & Co., 108 East Third Street, Dayton, Ohio, are engineers.

**Iowa, Milford**—City Council plans early call for bids for equipment for new municipal electric light and power plant, for which fund of $70,000 has been arranged. Buell & Winter Engineering Co., Insurance Exchange Building, Sioux City, Iowa, is consulting engineer.

**Ky., Fort Thomas**—Common Council is completing plans for new municipal electric light and power plant, estimated to cost $250,000, and plans early call for equipment bids. Financing is being arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

**Md., Baltimore**—Old Maryland Rye Distilling Co., plans installation of electric power equipment in connection with extensions and improvements in plant. Cost about $40,000. G. E. Stone and Alexander Porter, 512 St. Paul Street, are architects in charge.

**Mich., Flint**—AC Spark Plug Co., Inc., plans installation of motors and other electric power equipment in new one-story addition, 45x250 ft., to be used for production of steel bearings, etc. Entire project will cost about $70,000. Company is a division of General Motors Corporation, Detroit.

**Mich., Marquette**—City Council is planning extensions of power transmission line to United States Forest Service station at Dukes and vicinity, with power substation facilities.

**Minn., Luverne** — Common Council is considering construction of a new municipal artificial gas plant and system. A bond issue of $30,000 is being arranged. C. I. Tenney Engineering Co., Rand Tower Building, Minneapolis, Minn., is consulting engineer.

**Minn., Melrose**—Schatzbrau Brewing Co., Melrose, plans installation of electric power equipment in new three-story and basement plant. Work on unit will proceed at once. Equipment purchases will soon be made. Entire project will cost over $150,000. L. F. Schafhausen, 2652 Bryant Avenue South, Minneapolis, Minn., is architect.

**Minn., Moorhead**—Board of Aldermen is arranging special election to approve bonds for $92,000, fund to be used for extensions and improvements in municipal electric light ant power plant, including purchase of new boilers, stokers and other equipment. Ralph D. Thomas, 1200 Second Avenue South, Minneapolis, Minn., is consulting engineer.

**Minn., St. Cloud**—City Council has plans nearing completion for new municipal electric light and power plant, and is securing financing through Federal aid. Proposed to ask equipment bids at early date. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

**Miss., Meridian** — Common Council has plans maturing for a new municipal electric light and power plant. Financing is being arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

**Mo., Linden**—A. M. Jones Distillery, Inc., Kansas City, Mo., care of Fred C. Gunn, National Fidelity Life Building, Kansas City, architect, recently organized, plans installation of electric power equipment in new distilling plant on site near Linden. A one-story power house will be built. Entire project will cost close to $90,000.

**Mo., St. Louis**—Cupples-Hesse Envelope & Lithographing Co., 4173 North Kingshighway, plans installation of electric power equipment in new one-story factory addition, entire project estimated to cost over $65,000. Austin Co., Arcade Building, is engineer.

**Mo., St. Louis**—A. H. Lewis Medicine Co., Fourth and Spruce Streets, plans installation of motors and other electric power equipment in new multi-story addition. Entire project will cost close to $100,000.

**N. Y., Niagara Falls** — American Sales Book Co., 3000 Highland Avenue, plans installation of electric power equipment in new plant addition. Entire project will cost about $65,000.

**Ohio, Canton**—Ohio River Power Co., Canton, Ohio, plans new transmission line over Muskingum River, near Philo, Ohio, where company has a generating station. Federal permission has been asked. Company engineering department is in charge.

**Ohio, Cincinnati** — Kroger Grocery & Baking Co., 35 East Seventh Street, plans installation of motors and other electric power equipment in new packing plant addition, two-story and basement, 160x300 ft. Entire project will cost about $500,000. Tietig & Lee, 34 West Sixth Street, are architects.

**Ohio, Dayton**—Dayton Rubber Mfg. Co., 2345 Riverview Avenue, manufacturer of tires and rubber products, plans installation of electric power equipment in connection with expansion and improvement program, including new addition. Entire project will cost about $60,000. Geyer & Neuffer, Arcade Building, are architects.

**Ohio, Niles**—City Council is securing estimates of cost and details of a proposed municipal electric light and power plant, totaling $500,000, with equipment. Bert Holloway, superintendent of water and light, is in charge.

**Ont., London** — Richmond Hosiery Co., plans installation of electric power equipment in new three-story addition to mill. Entire project will cost close to $50,000.

**Que., Montreal**—Executive Council of Montreal, City Hall, has authorized installation of new ornamental lighting system in Laurier and St. Michael districts. Fund of $35,000 has been voted for work.

**S. C., Greenwood**—Board of County Commissioners, Greenwood, plans new hydroelectric power plant on Saluda River, vicinity of Chappells, S. C., including transmission lines to different points in county. Entire project is estimated to cost close to $1,000,000. Financing is being arranged through Federal aid.

**Tenn., Old Hickory**—duPont Rayon Co., 350 Fifth Avenue, New York, has approved plans for extensions and improvements in power house at rayon mill at Old Hickory. Cost over $60,000.

**Texas, Dallas**—Texas Potash Corporation, Republic Bank Building, plans installation of electric power equipment in proposed new refining plant on site now being selected. A power station will be built. Entire project will cost over $100,000.

**Wis., Green Bay**—Hall's Distillery, Inc., recently organized, plans installation of electric power equipment in connection with expansion and improvement program at former Hagemeister Brewery, which has been acquired for a new distillery. Entire project will cost about $100,000.